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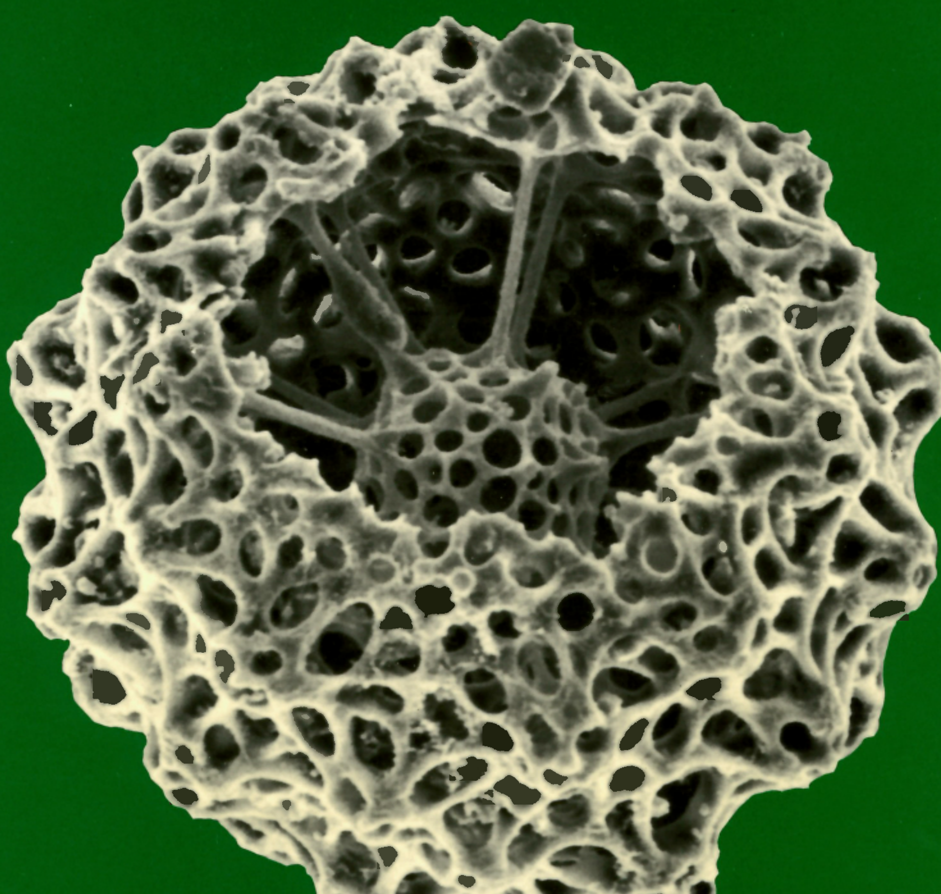
LOWER AND MIDDLE JURASSIC RADIOLARIAN BIOSTRATIGRAPHY AND SYSTEMATIC PALEONTOLOGY, QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA

E.S. Carter, B.E.B. Cameron, and P.L. Smith



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PREFACE

Extensive geological investigation of Mesozoic strata of the Pacific Rim is currently underway to determine the hydrocarbon potential of these rocks. Precise biostratigraphic control is essential for advances in this type of exploration, and substantial new information on the Jurassic biostratigraphy and taxonomy of Jurassic radiolarians from the Queen Charlotte Islands, British Columbia is presented in this report. Five new genera and forty-two new species are described, most of which have restricted, and therefore useful, biostratigraphic ranges. A preliminary radiolarian zonation is proposed, calibrated with associated ammonite and foraminiferal faunas. This zonation refines existing stratigraphic control and thus constitutes an extremely useful and practical contribution to hydrocarbon exploration.

R.A. Price
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

Des recherches géologiques extensives des strates du Mésozoïque de la marge du Pacifique sont fréquemment en marche afin de déterminer le potentiel d'hydrocarbures de ces roches. Un contrôle biostratigraphique précis est essentiel pour pousser plus avant ce genre d'exploration; de plus, on présente dans ce rapport de nouvelles données substantielles sur la biostratigraphie et sur la taxonomie des radiolaires du Jurassique des îles de la Reine-Charlotte en Columbie-Britannique. Cinq nouveaux genres et quarante-deux nouvelles espèces sont décrits, la plupart d'entre eux sont limités dans le temps et, de ce fait, utiles pour la datation biostratigraphique. Une zonation préliminaire de radiolaires est proposée et calibrée en association avec les ammonites et les foraminifères. Cette zonation apporte une plus grande précision de la stratigraphie et partant une utilisation extrêmement utile et une contribution pratique pour l'exploration des hydrocarbures.

R.A. Price, sous-ministre adjoint
Commission géologique du Canada

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Abstract

Radiolaria are used to construct an informal zonation (seven zones, numbered one through seven) for Jurassic strata of late Pliensbachian to early Bajocian age from the Fannin, Whiteaves, Phantom Creek and Graham Island formations, Queen Charlotte Islands, British Columbia. The study emphasizes Toarcian Radiolaria, because hitherto little was known of their morphology and distribution; rich, well preserved assemblages of middle to late Toarcian radiolarians have now been recovered from limestones of the Whiteaves and Phantom Creek formations. Ammonites collected as part of a recently completed stratigraphic study of the Jurassic sequence provide excellent control for dating all radiolarian assemblages. Forty-two new species and five new genera of radiolarians are described herein.

The sequence of co-occurring ammonites indicates that Zone 1 is late Pliensbachian (Carlottense Zone) and Zone 7 is early Bajocian (*Docidoceras widebayense* Assemblage Zone and an unnamed interval underlying the *Parabigotites crassicostatus* Assemblage Zone). Corresponding ammonite zones for radiolarian zones 2 to 6 (Toarcian to Aalenian) have not yet been worked out for North America; thus Zone 2 is early middle Toarcian, Zones 3 and 4 are late middle to early late Toarcian, Zone 5 is late Toarcian, and Zone 6 is Aalenian.

Radiolaria from the Queen Charlotte Islands (part of the displaced terrane of Wrangellia) compare well with Tethyan assemblages from western North America, the Mediterranean area and Japan.

Résumé

On utilise les radiolaires pour établir une zonation informelle (sept zones, numérotées de 1 à 7) des strates jurassiques, comprises entre le Pliensbachien supérieur et le Bajocien inférieur, et appartenant aux formations de Fannin, Whiteaves, Phantom Creek et Graham Island, dans les îles de la Reine-Charlotte, en Colombie-Britannique. Dans cette étude, on s'intéresse principalement aux radiolaires du Toarcien, pour la raison que jusqu'à présent, on connaissait très peu leur morphologie et leur distribution; on a maintenant extrait des calcaires des formations de Whiteaves et de Phantom Creek des assemblages riches et bien conservés de radiolaires du Toarcien moyen à supérieur. Les ammonites recueillies dans le cadre d'une étude stratigraphique récemment complétée de la séquence jurassique, nous fournissent un excellent point de repère pour la datation des assemblages de radiolaires. Dans cet article, on décrit 42 nouvelles espèces et 5 nouveaux genres de radiolaires.

La séquence d'ammonites présentes avec les radiolaires indique que la zone 1 est du Pliensbachien supérieur (zone à Carlottense), et que la zone 7 est du Bajocien inférieur (zone d'assemblage à *Docidoceras widebayense* et un intervalle non dénommé sous-jacent à la zone d'assemblage à *Parabigotites crassicostatus*). On n'a pas encore établi, dans le cas de l'Amérique du Nord, de zones à ammonites correspondant aux zones 2 à 6 à radiolaires (Toarcien à Aalénien); cette zone 2 date du début du Toarcien moyen, les zones 3 et 4 de la fin du Toarcien moyen au début du Toarcien supérieur, la zone 5 du Toarcien supérieur, et la zone 6 de l'Aalénien.

Les radiolaires des îles de la Reine-Charlotte (une partie du terrane déplacé qui constitue Wrangellia) présentent une bonne concordance avec les assemblages typiques de la Téthys, rencontrés dans l'ouest de l'Amérique du Nord, la région méditerranéenne et le Japon.

Summary

The study of Jurassic Radiolaria is still in its infancy. Twenty years ago, Sutherland Brown (1968) first recognized Radiolaria from the Queen Charlotte Islands; they have been studied in detail only since the late 1970's. Their biostratigraphic usefulness could not be assessed until extensive collecting combined with a detailed examination of the rocks had taken place. A recently completed study of Jurassic stratigraphy of the Queen Charlotte Islands, by B.E.B. Cameron and H.W. Tipper (1985), has now provided the framework on which to base further radiolarian studies.

This report deals with Radiolaria of late Pliensbachian to early Bajocian age from the Fannin, Whiteaves and Phantom Creek formations of the Maude Group, and the Graham Island Formation of the Yakoun Group. Limestone samples collected from measured sections on Maude Island and central Graham Island have yielded rich assemblages of radiolarians. The study emphasizes Toarcian Radiolaria because formerly, little was known of their morphology and distribution; extremely diverse, well preserved assemblages of middle to late Toarcian radiolarians have now been recovered from the Whiteaves and Phantom Creek formations. One hundred and sixty-eight species of Radiolaria have been examined. Over half the species are new, and many demonstrate restricted biostratigraphic ranges. Five new genera and forty-two new species of Radiolaria are described herein; many other species are recorded informally.

Radiolarian assemblages are dated by using closely associated suites of ammonites, which provide excellent stratigraphic control; age is further constrained by associated foraminiferal faunas and, to a lesser degree, by comparison with other radiolarian assemblages from western North America. Ammonites are referred to North American ammonite zones for the Pliensbachian and Bajocian, whereas Toarcian ammonite sequences are provisionally compared to the Northwest European succession until work in progress can establish a North American zonal scheme.

Detailed and well-dated local zonations are of great value in hydrocarbon exploration and are essential to the development of global biostratigraphy. The preliminary radiolarian zonation proposed herein encompasses rocks that are shown to be late Pliensbachian, Toarcian and early Bajocian in age, on the basis of co-occurring ammonites. Seven radiolarian zones are distinguished as informal units, numbered one through seven. Zone 1 is late Pliensbachian (Carlottense Zone) and Zone 7 is early Bajocian (*Docidoceras widebayense* Assemblage Zone and an unnamed interval beneath the *Parabigotites crassicostatus* Assemblage Zone). Zone 2 is early middle Toarcian (approximately equivalent to the Bifrons Zone), Zones 3 and 4 are late middle to early late Toarcian, Zone 5 is late Toarcian, and Zone 6 is Aalenian. Although these zones apply only to the Queen Charlotte Islands at present, it is probable that further testing in other areas will prove them to be of more regional value. The following is a synopsis of zonal indicators for the proposed radiolarian zones:

Zone 1. Base is undetermined (no subjacent fauna to provide basis for definition). Top of zone marked by final appearance of *Katroma ninstintsi* n. sp., *Bipedis fannini* n. sp., and *Canutus* s.s.

Zone 2. Base recognized by first appearance of *Protoperispyridium*, *Parvicingula* s.l., and *Emiluvia*. Top of zone marked by final appearance of *Jacus magnificus* n. sp. and *Parvicingula* (?) sp. A (this report).

Zone 3. Base recognized by first appearance of *Turanta morinae* and *Elodium* n. gen.

Zone 4. Base recognized by first appearance of *Tripocyclia* s.s. and *Maudia* n. gen. Top of zone marked by final appearance of *Crucella angulosa* n. sp. and *Rolumbus kiustaense* n. sp.

Zone 5. Base recognized by first appearance of *Higumastra*. Top of zone marked by final appearance of *Canoptum* s.s. and *Spongiostoma saccideon* n. sp. (approximately equivalent to the top of Subzone $1A_2$ of Pessagno et al., 1987).

Zone 6. Base placed immediately above final appearance of *Canoptum* s.s. Top of zone marked by final appearance of *Turanta morinae*, *Hsuum optimus* n. sp., and *Elodium* n. gen. (approximately equivalent to top of Subzone $1A_1$ of Pessagno et al., 1987).

Zone 7. Base recognized by first appearance of *Parvicingula matura* and *Parvicingula* sp. B (this report). Top of zone undetermined.

Jurassic faunas in the Queen Charlotte Islands are allied with those in the Tethyan Faunal Province. The ammonite fauna is very diverse and more closely related to the faunas of the conterminous United States, southern Europe, North Africa, and South America than to those of northern Europe and cratonic northern North America. The foraminiferal faunas also appear to be Tethyan but cosmopolitan species compare well with those of the Northwest European Province. The radiolarians too are diverse (particularly the Hagiastridae and Patulibracchiidae) and many are similar or comparable to coeval species of Tethyan aspect from California, east-central Oregon, the Mediterranean area (chiefly Greece and Turkey), and Japan.

New genera described in Part 2 of this report include: *Caltrop*, *Elodium*, *Maudia*, *Spongiostoma* and *Tympaneides*. New species include: *Acaeniotyle* (?) *ghostensis*, *Alievium* ? *juskatlaensis*, *Amphibrachium* (?) *phantomensis*, *Bipedis fannini*, *Caltrop nodosum*, *Crubus wilsonensis*, *Crucella angulosa*, *Drulanta edenshawi*, *Elodium cameroni*, *Elodium nadenensis*, *Emiluvia acantha*, *Emiluvia* (?) *moresbyensis*, *Emiluvia oldmassetensis*, *Emiluvia splendida*, *Eucyrtidium elementarius*, *Homeoparonaella reciproca*, *Hsuum optimus*, *Jacus magnificus*, *Katroma ninstintsi*, *Maudia yakounense*, *Orbiculiforma kwunaensis*, *Orbiculiforma trispinula*, *Paronaella grahamensis*, *Paronaella skowkonaensis*, *Paronaella spongiosa*, *Paronaella porosa*, *Paronaella variabilis*, *Parvicingula aculeata*, *Protoperispyridium* (?) *hippaensis*, *Praeconocaryomma* (?) *fasciata*, *Praeconocaryomma whiteavesi*, *Protounuma paulsmithi*, *Rolumbus kiustaense*, *Staurolonche ellsi*, *Spongiostoma saccideon*, *Spongostaurus cruciformis*, *Spongostaurus pugiunculus*, *Spongotripus incomptus*, *Spongotrochus tanaensis*, *Stephanastrum* ? *magnum*, *Tripocyclia rosespitense*, and *Tympaneides charlottensis*.

This report presents substantial new information on the biostratigraphy and taxonomy of Jurassic radiolarians, particularly Toarcian forms. It provides a new tool of significant potential for hydrocarbon exploration in the Queen Charlotte Islands and indeed for all scientists working on the early and middle Jurassic of the Pacific Rim. Work continues on the Upper Triassic, Lower Jurassic (Hettangian – Sinemurian), and Cretaceous.

Sommaire

L'étude des radiolaires du Jurassique en est encore tout à fait à ses débuts. Il y a 20 ans, on a pour la première fois identifié des radiolaires provenant des îles de la Reine-Charlotte comme étant des micro-fossiles pélagiques (Sutherland Brown, 1968); ils ne sont étudiés en détail que depuis la fin des années 1970. On n'a pu évaluer leur utilité biostratigraphique, avant d'en avoir recueilli un très grand nombre, et en même temps d'avoir effectué une étude détaillée des roches. Une étude récemment complétée de la stratigraphie du Jurassique des îles de la Reine-Charlotte, faite par B.E.B. Cameron et H.W. Tipper (1985), constitue maintenant le cadre d'après lequel seront effectuées à l'avenir les études sur les radiolaires.

Dans ce rapport, on traite des radiolaires du Pliensbachien supérieur au Bajocien inférieur des formations de Fannin, de Whiteaves et de Phantom Creek, qui appartiennent au groupe de Maude, et de la formation de Graham Island appartenant au groupe de Yakoun. On a trouvé, dans les calcaires recueillis dans des coupes stratigraphiques mesurées de l'île Maude et du centre de l'île Graham, de riches assemblages de radiolaires. Dans cette étude, on s'intéresse particulièrement aux radiolaires du Toarcien, pour la raison que l'on ne connaissait autrefois que très peu de choses de la morphologie et de la distribution de ces radiolaires; on a maintenant extrait des formations de Whiteaves et de Phantom Creek des assemblages extrêmement diversifiés et bien préservés de radiolaires du Toarcien moyen à supérieur. On a examiné 168 espèces de radiolaires. Plus de la moitié des espèces sont nouvelles, et beaucoup démontrent l'existence d'intervalles biostratigraphiques restreints. Dans cet article, on décrit 5 genres et 42 espèces de radiolaires; on a noté un grand nombre d'autres espèces non-classées.

Pour dater les assemblages de radiolaires, on utilise des séries étroitement associées d'ammonites, qui constituent d'excellents points de repère stratigraphique; on définit encore mieux l'âge en utilisant les faunes associées de foraminifères, et dans une moindre mesure, en comparant ces assemblages de radiolaires à d'autres assemblages provenant de l'ouest de l'Amérique du Nord. Pour les ammonites, on se réfère aux zones ammonitiques nord-américaines du Pliensbachien et du Bajocien, tandis que l'on compare provisoirement les séquences ammonitiques du Toarcien à la succession typique du nord-ouest de l'Europe, jusqu' à ce que les recherches en cours nous permettent d'établir un schéma des zones d'Amérique du Nord.

Des zonations locales détaillées et correctement datées sont très importantes pour l'exploration pétrolière, et essentielles si l'on veut élaborer une biostratigraphie globale. La zonation préliminaire des radiolaires, telle que proposée dans cet article, englobe des roches que l'on a placées dans le Pliensbachien supérieur, le Toarcien et le Bajocien inférieur, d'après les ammonites coexistantes. On a identifié sept zones à radiolaires, qui constituent des unités non-classées numérotées de 1 à 7. La zone 1 date du Pliensbachien supérieur (zone à Carlottense), et la zone 7 du Bajocien inférieur (zone d'assemblage à *Docidoceras widebayense* et intervalle non dénommé, sous-jacent à la zone d'assemblage à *Parabigotites crassicostatus*). La zone 2 date du début du Toarcien moyen (elle est à peu près équivalente à la zone à Bifrons), les zones 3 et 4 de la fin du Toarcien moyen au début du Toarcien supérieur, la zone 5 du Toarcien supérieur, la zone 6 de l'Aalénien. Bien qu'actuellement, ces zones ne s'appliquent qu'aux îles de la Reine-Charlotte, l'exploration d'autres régions montrera sans doute qu'elles ont une valeur plus régionale. Ce qui suit est une synopsis des indicateurs zonaux, applicable aux zones à radiolaires proposées:

Zone 1. La base est indéterminée (la faune sous-jacente fournira la base d'identification). Le sommet de la zone est marqué par l'apparition finale de *Katroma ninstintsi* n. sp., de *Bipedis fannini* n. sp., et de *Canutus* s.s.

Zone 2. La base est reconnue d'après l'apparition initiale de *Protoperispyridium*, de *Parvicingula* s.l., et de *Emiluvia*. Le sommet de la zone est marqué par l'apparition finale de *Jacus magnificus* n. sp. et *Parvicingula* (?) sp. A (voyez le présent article).

Zone 3. La zone est reconnue d'après l'apparition initiale de *Turanta morinae* et de *Elodium* n. gen.

Zone 4. La base est reconnue d'après l'apparition initiale de *Tripocyclia* s.s. et de *Maudia* n. gen. Le sommet de la zone est défini d'après l'apparition finale de *Crucella angulosa* n. sp. et de *Rolumbus kiustaense* n. sp.

Zone 5. La base est reconnue d'après l'apparition initiale de *Higumastra*. Le sommet de la zone est marqué par l'apparition finale de *Canoptum* s.s. et de *Spongiostoma saccideon* n. sp. (approximativement équivalent au sommet de la sous-zone $1A_2$ telle que définie par Pessagno et al., 1987).

Zone 6. La base placée immédiatement au-dessus de la dernière apparition de *Canoptum* s.s. Le sommet de la zone est marqué par l'apparition finale de *Turanta morinae*, de *Hsuum optimus* n. sp. et de *Elodium* n. gen. (approximativement équivalent au sommet de la sous-zone $1A_1$ telle que définie par Pessagno et al., 1987).

Zone 7. La base est reconnue d'après l'apparition initiale de *Parvicingula matura* et de *Parvicingula* sp. B (dans le présent rapport). Le sommet de la zone est indéterminé.

Les faunes jurassiques des îles des la Reine-Charlotte sont apparentées à celles de la province faunique de la Téthys. La faune ammonitique est très diversifiée, et elle est plus étroitement apparentée aux faunes du territoire continental des États-Unis (à l'exception de l'Alaska), du sud de l'Europe, de l'Afrique du Nord et de l'Amérique du Nord, qu'à celles de l'Europe du Nord et du craton septentrional nord-américain. Il semble aussi que les faunes de foraminifères sont celles de la Téthys, mais les espèces cosmopolites sont très comparables à celles de la province européenne nord-occidentale. Les radiolaires aussi sont diversifiés (en particulier les Hagiastridae et les Patulibracchiidae) et un grand nombre d'entre eux sont semblables ou comparables à des espèces contemporaines typiques de la Téthys, provenant de la Californie, de la partie est-centrale de l'Orégon, de la région méditerranéenne (surtout de la Grèce et de la Turquie) et du Japon.

Parmi les nouveaux genres décrits dans la partie 2 de ce rapport, figurent: *Caltrop, Elodium, Maudia, Spongiostoma* et *Tympaneides*. Parmi les nouvelles espèces, citons: *Acaeniotyle ? ghostensis, Alievium ? juskatlaensis, Amphibrachium* (?) *phantomensis, Bipedis fannini, Caltrop nodosum, Crubus wilsonensis, Crucella angulosa, Drulanta edenshawi, Elodium cameroni,*

Elodium nadenensis, Emiluvia acantha, Emiluvia (?) *moresbyensis, Emiluvia oldmassetensis, Emiluvia splendida, Eucyrtidium elementarius, Homeoparonaella reciproca, Hsuum optimus, Jacus magnificus, Katroma ninstintsi, Maudia yakounense, Orbiculiforma kwunaensis, Orbiculiforma trispinula, Paronaella grahamensis, Paronaella skowkonaensis, Paronaella spongiosa, Paronaella porosa, Paronaella variabilis, Parvicingula aculeata, Protoperispyridium* (?) *hippaensis, Praeconocaryomma* (?) *fasciata, Praeconocaryomma whiteavesi, Protounuma paulsmithi, Rolumbus kiustaense, Staurolonche ellsi, Spongiostoma saccideon, Spongostaurus cruciformis, Spongostaurus pugiunculus, Spongotripus incomptus, Spongotrochus tanaensis, Stephanastrum ? magnum, Tripocyclia rosespitense,* et *Tympaneides charlottensis.*

Dans ce rapport, on présente des quantités substantielles de renseignements nouveaux sur la biostratigraphie et la taxonomie des radiolaires du Jurassique, en particulier des formes datant du Toarcien. Cette information est un outil nouveau et relativement importante pour le réalisation de l'exploration pétrolière dans les îles de la Reine-Charlotte, et fort utile à tous les chercheurs qui étudient le Jurassique inférieur et le Jurassique moyen de la bordure du Pacifique. On poursuit les recherches sur le Trias supérieur, le Jurassique inférieur (Hettangien-Sinémurien) et le Crétacé.

PART 1. LITHOSTRATIGRAPHY AND BIOSTRATIGRAPHY

(E.S. Carter, B.E.B. Cameron, and P.L. Smith)

INTRODUCTION

This study deals with Pliensbachian to Bajocian Radiolaria of the Queen Charlotte Islands with emphasis on the Toarcian, an interval neglected in the past. The study is restricted to the Fannin, Whiteaves, Phantom Creek and Graham Island formations of the Maude and Yakoun groups (Cameron and Tipper, 1985), which outcrop mainly in south central Graham Island and around Skidegate Inlet (Fig. 1). The development of a workable biostratigraphic framework is important to potential oil exploration both on and offshore of the Queen Charlotte Islands, since reports of oil stain and bitumen (Cameron and Tipper, 1981, 1985) in many parts of the Jurassic sequence indicate probable hydrocarbon source beds.

The objectives of this study were:

1. To contribute to the developing worldwide zonation of the Jurassic on the basis of radiolarians.

2. To understand better the late Pliensbachian to early Bajocian sequence of Radiolaria and how they relate to the associated ammonoid and foraminiferal faunas.

3. To describe significant new taxa. This is particularly important as lower and middle Jurassic Radiolaria in general and Toarcian Radiolaria in particular are poorly known worldwide.

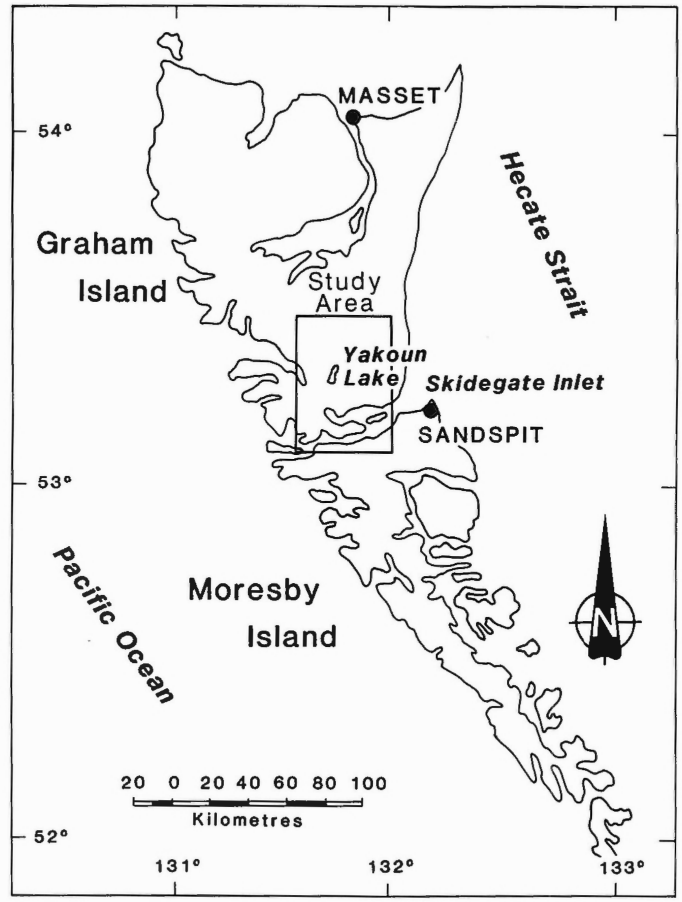


Figure 1. Index map of Queen Charlotte Islands.

Previous work

Geological investigations in the Queen Charlotte Islands prior to 1916 were oriented toward the development of coal and mineral reserves. Initial study in 1872 by Richardson (1873) was followed in 1878 by the classical work of G.M. Dawson (1880), who examined the geography and geology of the central and eastern shores of the islands as well as the fauna, flora and anthropology. Dawson separated the sedimentary rocks of central Graham Island into five subdivisions and believed them all to be of Cretaceous age. Whiteaves (1876, 1883, 1884, 1900) studied the paleontological collections and saw only one ammonite fauna; a transitional one encompassing the Upper Jurassic and lowermost Cretaceous. In 1913-14, Mackenzie (1916) systematically studied Graham Island, revising Dawson's stratigraphy; he subdivided the Jurassic beds into two formations: the Maude and the Yakoun, which he considered Lower and Middle Jurassic, respectively. In 1921, F.H. McLearn collected in Skidegate Inlet, published extensively on Jurassic ammonites (1927, 1929, 1930, 1932), and summarized the Jurassic stratigraphy (1949). He believed ammonites of the Maude Formation (at Maude Island and other locations on Skidegate Inlet, Figure 2C) were Toarcian only, and those of the Yakoun were early Bajocian. Frebold (1967) determined the age of the Maude as late Sinemurian, early Pliensbachian, Toarcian and possibly late Pliensbachian, during a study of the genus *Fanninoceras*. Sutherland Brown (1968) mapped both Graham and Moresby islands in detail.

In 1974, the Geological Survey of Canada began a series of biostratigraphic studies of Jurassic formations in the Queen Charlotte Islands (Tipper, 1976, 1977; Tipper and Cameron, 1979, 1980; Cameron and Tipper, 1981, 1985). Sections were examined on Maude Island, at Whiteaves Bay and in the Yakoun River area on central Graham Island. Studies of ammonites collected so far indicate that all stages from Sinemurian to Callovian are represented, although not as a complete section. Results of that work, elevating the Kunga, Maude and Yakoun formations to group level, established many new, mappable stratigraphic units (Cameron and Tipper, 1985). Ongoing research by Cameron is expected to establish a Lower to Middle Jurassic foraminiferal zonation and Tipper, Smith and colleagues are working toward a Western North American zonation for the Lower Jurassic based, in part, on the Queen Charlotte Island ammonites (Smith et al., in press).

Radiolarian work in this area was begun in the late 1970's when Pessagno initiated studies of Upper Triassic and Lower Jurassic Radiolaria. Samples of late Norian to late Pliensbachian age were collected from Kunga Island, Maude Island and Whiteaves Bay on northern Moresby Island. Results were confined primarily to the description of new taxa with some preliminary range zone data (Pessagno and Blome, 1980; Pessagno and Whalen, 1982; Pessagno, Whalen, and Yeh, 1986). Major zonal schemes, which incorporate some Queen Charlotte data, have been proposed by Blome (1984) and Pessagno et al. (1987).

Acknowledgments

Fruitful discussions with Emile Pessagno (University of Texas at Dallas) and Patrick De Wever (Université Pierre et Marie Curie) are gratefully acknowledged. Special thanks to H.W. Tipper of the Geological Survey of Canada for providing ages of associated ammonites, and useful comments and discussion; to D.G. Taylor (Portland State University) for discussions on Bajocian ammonites; to G.E. Rouse (University of British Columbia) for identification of the algal cyst; and to R.V. Best (University of British Columbia) for critical reading of the systematic paleontology.

The majority of scanning electron photomicrographs were taken by Marji Johns, Geological Survey of Canada, Pacific Geoscience Centre, Sidney, B.C. G. Hodge (University of British Columbia) drafted some of the figures.

Finally, Dr. Patrick De Wever and Dr. H.W. Tipper are thanked for their critical review of the manuscript; most of their suggestions have been incorporated.

This work was supported by Natural Science and Engineering Research Council of Canada Grant A 588493 to P.L. Smith. The Geological Survey of Canada provided field support, sample residues, and stratigraphic information.

LITHOSTRATIGRAPHY

The Jurassic succession in the Queen Charlotte Islands, comprising the upper Kunga, the Maude, Yakoun, and Moresby groups (Cameron and Tipper, 1985) together with a thick Triassic sequence of oceanic basalt and limestone, was deposited on the tectonostratigraphic terrane Wrangellia (see Table 1). Volcanic rocks are predominant in the Jurassic, but sedimentary sequences, normally thin and in part volcaniclastic, are interbedded with them. All are marine with the exception of a small part of the Richardson Bay Formation (Yakoun Group). This report deals with upper Pliensbachian to lower Bajocian rocks of the upper Maude and lower Yakoun formations (sensu Sutherland Brown, 1968) now subdivided and newly defined by Cameron and Tipper (1985) as the Fannin, Whiteaves and Phantom Creek formations of the Maude Group, and the Graham Island Formation of the Yakoun Group. A brief account of the stratigraphy as used here follows, as well as a few additional comments on localities relevant to this study. For a complete discussion of Jurassic stratigraphy in the Queen Charlotte Islands see Cameron and Tipper (1985).

Maude Group

The Maude Group includes, in ascending order, the Ghost Creek, Rennell Junction, Fannin, Whiteaves and Phantom Creek formations. All are thin sedimentary marine units that are exposed in small, widely scattered discontinuous outcrops mostly in the central part of the Queen Charlotte Islands (Figs. 1, 2). Where exposed, the Maude Group lies with gradational contact on the Sandilands Formation of the Kunga Group. The uppermost unit of the Maude Group, the Phantom Creek, is overlain unconformably by the Graham Island Formation, lowermost unit of the Yakoun Group; the transition is abrupt, normally signalled by an increase in volcaniclastic material. The Phantom Creek Formation invariably consists of sandstone, whereas the Graham Island Formation consists typically of interbedded shale, siltstone and sandstone, all highly tuffaceous.

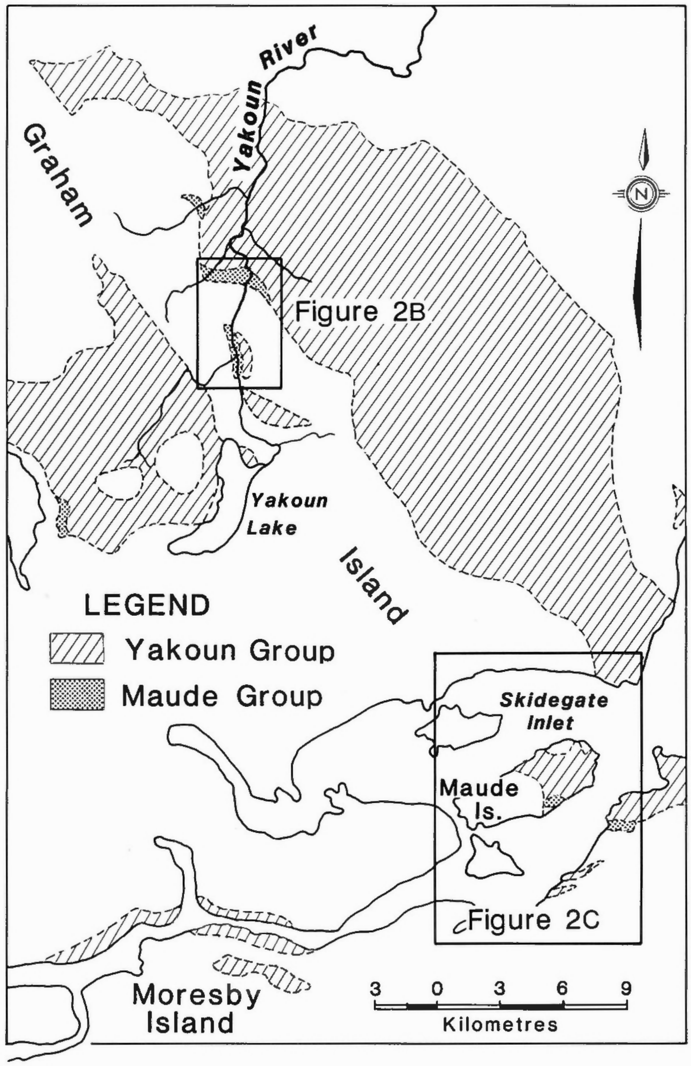


Figure 2A. Study area showing distribution of the Maude and Yakoun groups in the central Queen Charlotte Islands.

Fannin Formation

The Fannin Formation is exposed in creek outcrops on Maude Island and is partly represented in a few stream cuts and quarries on Graham Island. It is a coarse clastic unit composed of hard tuffaceous sandstone, minor siltstone, rare thin shale and a few limestone interbeds and lenses. Glauconite grains are common and beds containing chamosite ooliths have been noted in the upper part of the formation at several localities. These, combined with abundant benthic macrofossils, foraminifers and trace fossils (e.g., *Thalassinoides*) suggest shallow marine deposition.

On Maude Island, the most complete section (Fig. 3; stratigraphic section 4) is just west of Fannin Bay on a creek about midway through the type section of the Maude Formation (see Sutherland Brown, 1968, p. 64). Although no ammonites have been collected here, Cameron and Tipper (1985) believe this creek section is lithologically equivalent in part to a prominent exposure on the beach of Fannin Bay where limy coquinoid nodular beds contain an abundant "*Tiltoniceras*" *propinquum* fauna (of Cameron and Tipper, 1985). The Fannin Formation is late Pliensbachian to earliest Toarcian in age.

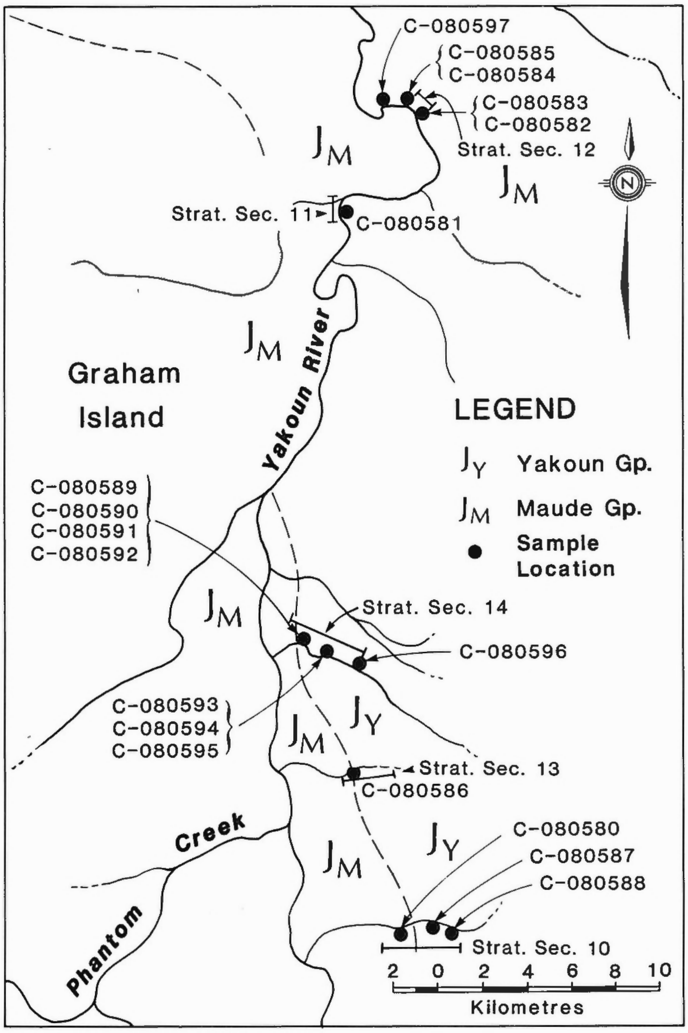


Figure 2B. GSC sample localities in the Yakoun River area of central Graham Island. Stratigraphic sections 10 to 14 after Cameron and Tipper (1985).

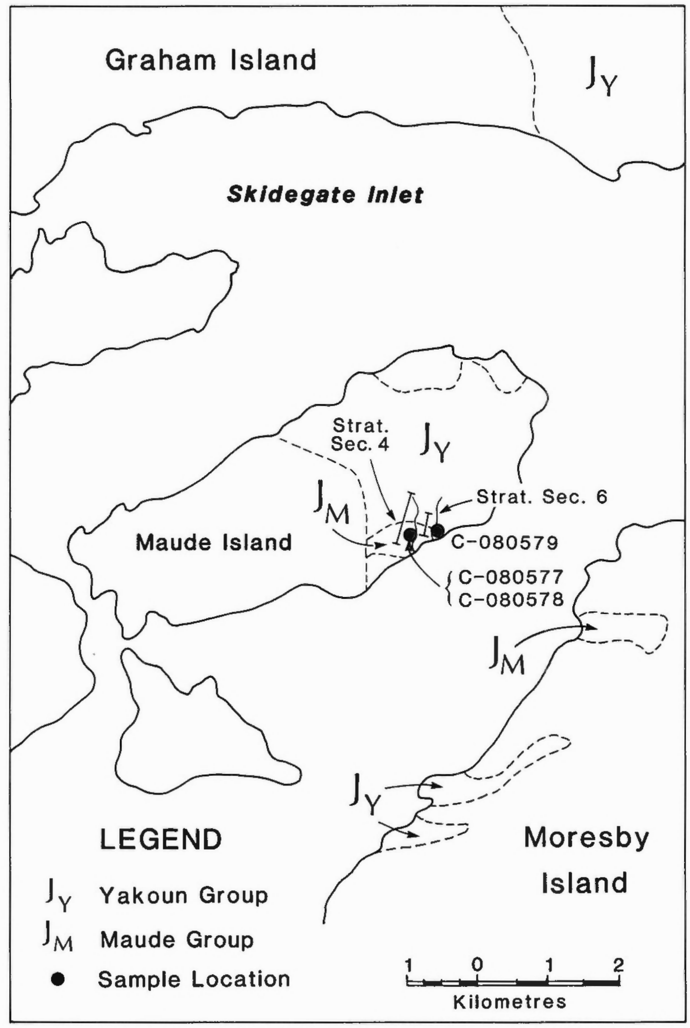


Figure 2C. GSC localities on Maude Island. Stratigraphic sections 4 and 6 after Cameron and Tipper (1985).

Whiteaves Formation

The Whiteaves Formation is a pale grey-green weathering shale unit. It is found in creek and shoreline exposures around Skidegate Inlet, at Atli Inlet, Lyell Island, southern Moresby Island, in creek beds and roadcuts on Graham Island, and is best exposed along the Yakoun River on Graham Island. Cameron and Tipper (1985) have divided the formation into two informal members, a lower, septarian shale member, and an upper, concretionary shale member. Part sections of both members occur on Maude Island; much thicker, and more complete, exposures are found on Graham Island. Although the presence of glauconite and pyrite, common in these sediments, might suggest reducing conditions, abundant and diverse foraminifers indicate well oxygenated bottom conditions, but probably at greater depositional depth than in the Fannin Formation. A limestone nodule from a small creek (Fig. 3; stratigraphic section 6) has yielded an extremely rich, pyritized radiolarian fauna. Several sections of the middle Toarcian Whiteaves Formation are presented in Figure 3.

Phantom Creek Formation

The uppermost unit of the Maude Group, the Phantom Creek Formation, is best exposed on central Graham Island along the Yakoun River and in isolated exposures in stream cuts and quarries. Only the uppermost parts of the unit are present in the Skidegate Inlet area. The formation comprises brown- to buff-weathering, partly calcareous, fine to coarse grained sandstone with thin shale interbeds in the lower part; it is generally a resistant unit. Cameron and Tipper (1985) have divided it into two informal members: the lower, coquinoid sandstone, member and the upper, belemnite sandstone, member, possibly with a paraconformity between the two. The formation is thickest on Graham Island where both members are present; in Skidegate Inlet the lower member is missing, at least in most sections, and the belemnite sandstone member rests directly on the Whiteaves Formation. Lithological and faunal evidence suggests that the lower member was deposited in a high energy, shallow water environment, whereas a slightly deepening trend is indicated during deposition of the upper member (Cameron

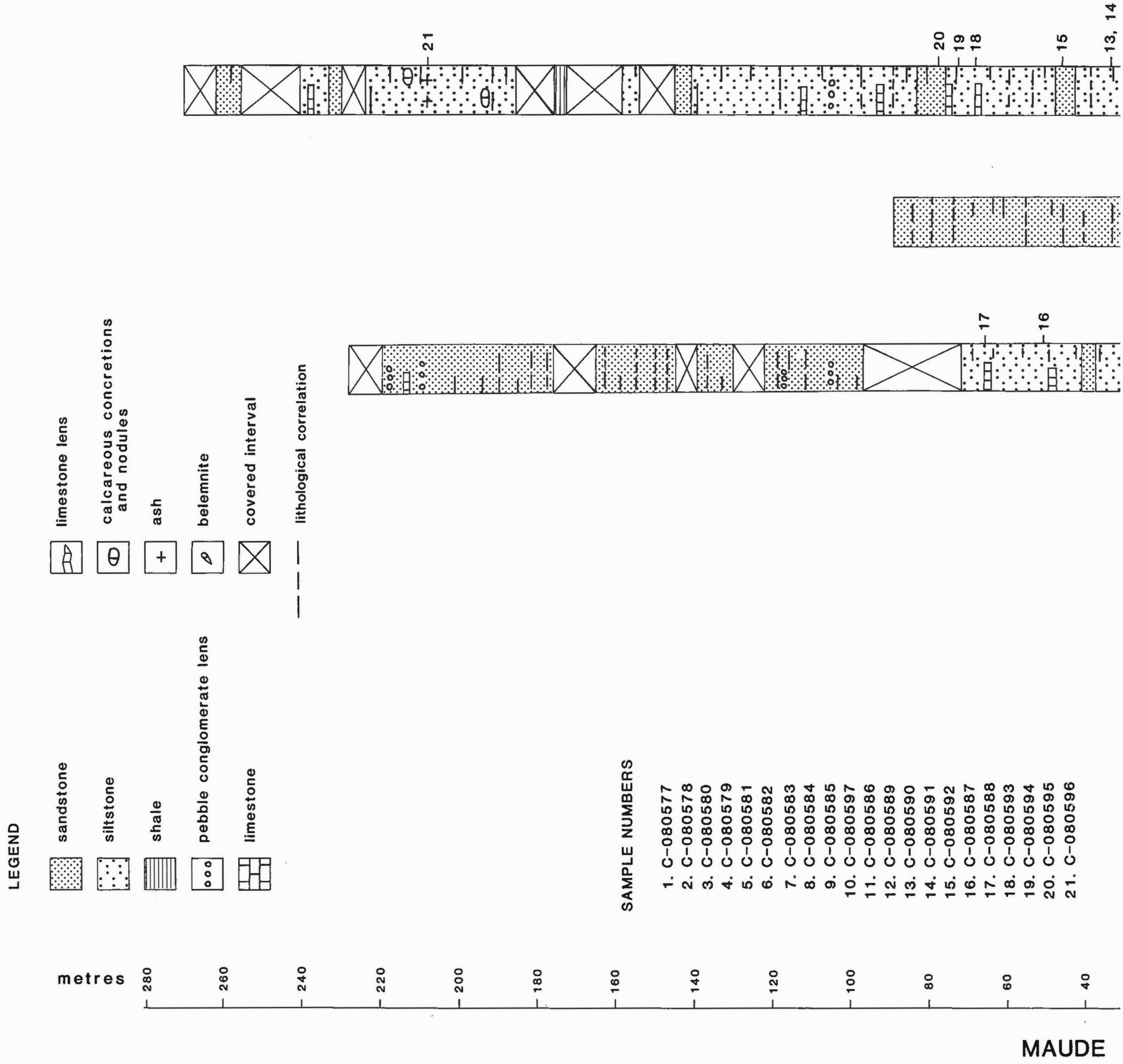


Figure 3. *Lithostratigraphy of sections, their broad correlation, and the stratigraphic position of radiolarian samples. Stratigraphic sections modified from Cameron and Tipper (1985).*

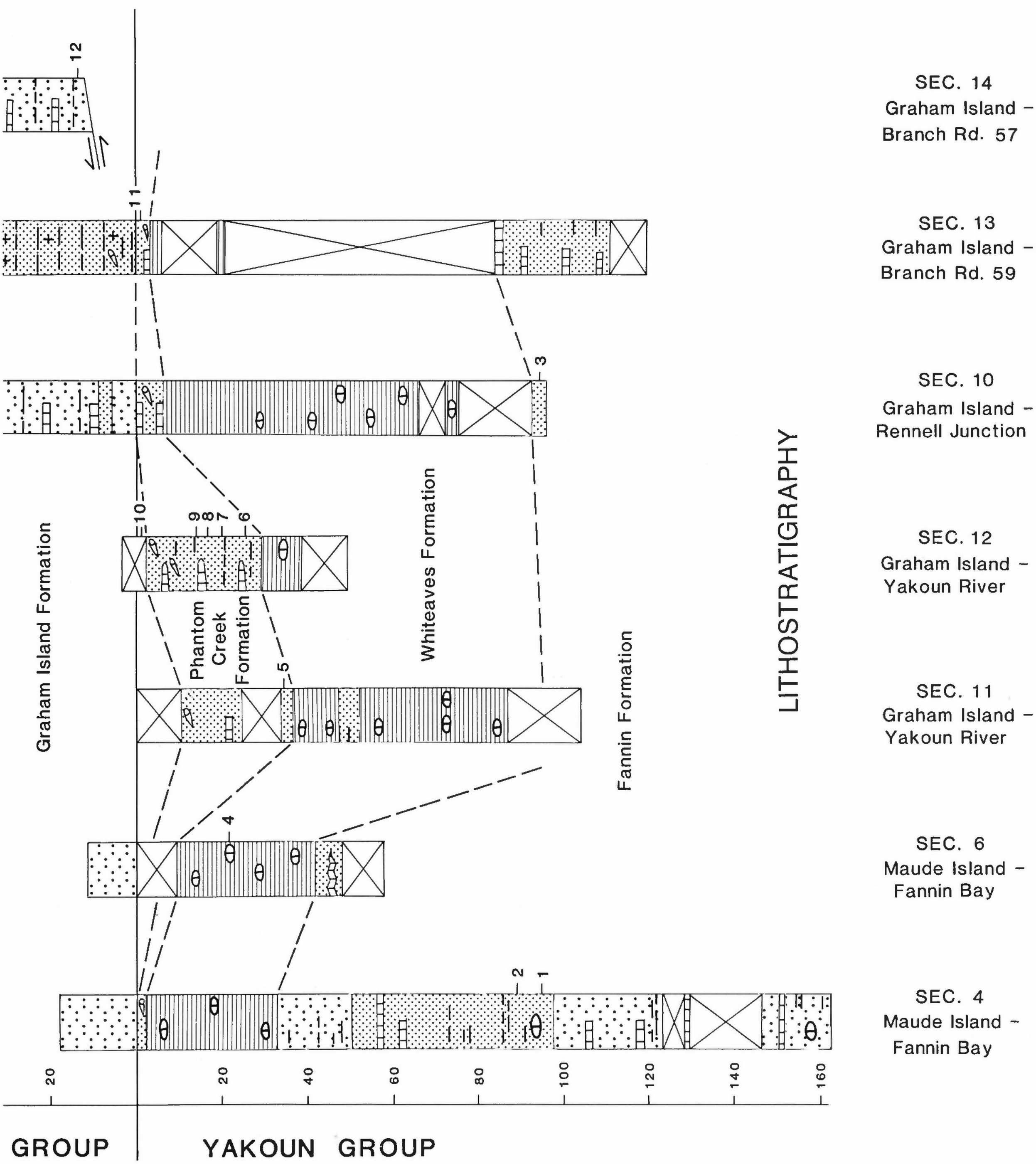

LITHOSTRATIGRAPHY
SEC. 14 Graham Island - Branch Rd. 57
SEC. 13 Graham Island - Branch Rd. 59
SEC. 10 Graham Island - Rennell Junction
SEC. 12 Graham Island - Yakoun River
SEC. 11 Graham Island - Yakoun River
SEC. 6 Maude Island - Fannin Bay
SEC. 4 Maude Island - Fannin Bay
Graham Island Formation
Phantom Creek Formation
Whiteaves Formation
Fannin Formation
GROUP
YAKOUN GROUP
20
20
40
60
80
100
120
140
160

TABLE 1

Jurassic formations of the Queen Charlotte Islands

AGE		STRATIGRAPHIC UNITS						Stratigraphic interval covered in this paper
			Sutherland Brown (1968)		Cameron and Tipper (1985) and this paper			
				Thickness in feet			Thickness in metres	
MIDDLE JURASSIC	Callovian	VANCOUVER GROUP	Yakoun Formation	E member: 455	Moresby Group	Alliford Formation	60	
				D member: 800		Newcombe Formation	30–45	
				C member: 950		Robber Point Formation	15–90	
	Bajocian			B member: 100+	Yakoun Group	Richardson Bay Formation	90–640	
				A member: 650		Graham Island Formation	230–255	
	Aalenian		Conformable to slightly unconformable		Hiatus, paraconformity			
			Maude Formation	Up to 600	Maude Group	Phantom Creek Formation	8–30	
LOWER JURASSIC	Toarcian					Whiteaves Formation	18–85	
						Fannin Formation	26–64	
	Pliensbachian					Rennell Junction Formation	25–50	
						Ghost Creek Formation	45–68	
	Sinemurian		Conformable contact					
			Kunga Formation	Black argillite member up to 1900	Kunga Group	Sandilands Formation	500+	

and Tipper, 1985). Rich assemblages of well preserved radiolarians are found in the sandy limestone lenses of the unit, particularly in the coquinoid sandstone member.

The lowest beds of the Phantom Creek Formation (Fig. 3) are middle to late Toarcian and the belemnite sandstone is latest Toarcian to Aalenian.

Yakoun Group

The Yakoun Group, a dominantly pyroclastic unit with a wide range in composition and lithology, includes the Graham Island and the Richardson Bay formations (Cameron and Tipper, 1985). The Richardson Bay Formation comprises members B, C, and most of D of Sutherland Brown (1968); the Graham Island Formation is Sutherland Brown's member A, plus a new, conformably underlying informal member, the mottled siltstone (Cameron and Tipper, 1985). Both formations are present on Skidegate Inlet, whereas on central Graham Island, the Graham Island Formation attains its greatest thickness and the Richardson Bay Formation, although widespread, may be thinner. The areal extent of the Yakoun Group is shown in Figure 2. Radiolaria were studied only from the Graham Island Formation.

Graham Island Formation

The Graham Island Formation is well exposed both in the Skidegate Inlet area and on Graham Island (see Fig. 3; stratigraphic sections 10, 13, and 14). Cameron and Tipper (1985) have recognized four contrasting facies, which are designated as informal members: the shale-tuff member, mottled siltstone, volcanic sandstone and lapilli members. The first two members are distinctly different lithologically, but partly time equivalent. The shale-tuff member is exposed only on central Graham Island and the stratigraphically equivalent mottled siltstone member only on Skidegate Inlet. Similarly, the volcanic sandstone member is confined to Graham Island, whereas its stratigraphic equivalent, the lapilli member, is exposed in the Skidegate Inlet area. Radiolaria were studied from the shale-tuff and volcanic sandstone members on Graham Island only; unfortunately there are no limestones in the corresponding members on Skidegate Inlet. The shale-tuff member is composed of hard, slightly sandy shale and partly tuffaceous siltstone with minor sandstone and occasional fine calcareous sandstone interbeds. It is overlain by the volcanic sandstone member, which consists of interbedded sandstone, siltstone, calcareous sandstone and rare tuffaceous shale. The depositional environments of all lithologically variable, informal members of the Graham Island Formation described by Cameron and Tipper (1985) appear to be functions of their distance from the volcanic source. The shale-tuff member was probably deposited in deep water that was commonly euxinic, as indicated by its dark colour, the paucity of macrofauna, and the presence of a low diversity calcareous foraminiferal fauna. The volcanic sandstone member was apparently deposited in shallower water. The formation is early Bajocian in age, based on ammonite (sonninid) evidence.

Lithostratigraphic marker horizons

Three lithological markers are useful for correlating stratigraphic sections on Graham Island with those on Maude Island (Fig. 3):

1. The limy sandstone and buff, concretionary limestone beds of the Fannin Formation that contain abundant *Tiltoniceras propinquum*. They are further characterized by frequent occurrences of chamosite ooliths and are herein informally referred to as the chamosite beds. Rocks of similar lithology are found in a 30 m thick interval approximately 60 m above the base of stratigraphic section 4 and at the base of stratigraphic sections 6, 10, and 13. Total thickness of these beds has not been determined as, in some instances, covered intervals lie immediately below exposed beds, and in stratigraphic section 13, there is repetition by faulting (not shown in figured portion of section).

2. The Toarcian shales of the Whiteaves Formation, which are widely distributed and easily recognized by their distinctive green weathering. The lower member is characterized by septarian nodules, rare concretions, large ammonites, wood, and rare bivalves, whereas the upper member contains more abundant limy concretions and lacks septarian nodules. The two informal shale members on Graham Island are separated by a sandy layer, which marks an abrupt faunal change. Generally the Whiteaves Formation is thickest on Graham Island and includes both members; these may be seen on the Yakoun River (stratigraphic sections 11 and 12) and at Rennell Junction (stratigraphic section 10). On Maude Island north of Fannin Bay, only the upper member is present above the chamosite beds (stratigraphic section 6), whereas on a creek to the west (stratigraphic section 4) an erosional surface and paleosol caps the uppermost shales, which contain only rare limy concretions.

3. The coquinoid sandstone member of the Phantom Creek Formation, which is more variable lithologically, but is characteristically a pale grey sandstone. Its superpositional relationship above the distinctive Whiteaves Formation and its more resistant weathering make it a useful marker in the field. It is further characterized by abundant hammatoceratid ammonites. This member is present at all Graham Island localities, but is missing on Maude Island. The overlying belemnite sandstone member is distinctive, similar in lithology and its resistance to weathering, and is known from both Maude and Graham islands. In spite of the different ages of these two members, in all areas studied the Whiteaves Formation is overlain by a distinctive sandstone unit.

The great quantity of tuffaceous material in the Graham Island Formation undoubtedly explains the unusually thick sequences found on central Graham Island. Stratigraphic sections, even closely spaced, are lithologically heterogeneous and few markers are available for correlation. The relative position of radiolarian samples recorded in stratigraphic sections 10 and 14 has been determined by distance below the lowest recorded conglomerate bed.

RADIOLARIAN SAMPLES

Exposures of the Maude and Yakoun groups on central Graham Island, northern Moresby Island and in the Skidegate Inlet area in the central Queen Charlotte Islands are shown in Figure 2. Collections were made on Maude Island, Skidegate Inlet and in areas along the Yakoun River, central Graham Island.

On Maude Island, limestones at GSC localities C-080577, C-080578 and C-080579 were sampled at exposures on two creeks (stratigraphic sections 4 and 6) that flow into Fannin Bay on the southeast coast of the island. All other samples were collected from exposures along the Yakoun River approximately 2.5 km south of the confluence with Ghost Creek (stratigraphic sections 11 and 12), and from three more southerly creeks (stratigraphic sections 10, 13, and 14), which drain a prominent bluff approximately 0.5 km east of the river. For the location of stratigraphic sections and samples see Figure 2B, C. Detailed geographic and stratigraphic information of localities and lithological descriptions of sample residues are in Appendix 1. As this is a preliminary study, radiolarian-bearing limestones were collected as composite samples over approximately 3 metre intervals, a sampling interval consistent with the length of geological time encompassed by this study. With the exception of GSC locality C-080579 from a limestone nodule, all samples are from bedded concretionary limestone.

The distribution and relative abundance of Spumellaria and Nassellaria at each locality are shown in Figures 4 and 5. Precise number counts have not been used in this report because the range of variation in total numbers of Radiolaria per sample probably does not reflect true abundance. Reasons for this variability include:

1. Dilution of radiolarian fauna by terrigenous material in shelf or nearshore environments and by pyroclastic material in areas exposed to volcanism. The latter could partly explain the paucity of microfauna in some lower Bajocian samples. Observations of modern ocean beds indicate that the volume of tephra produced during subaerial eruptive phases of volcanism could effectively mask siliceous deposits (Garrison, 1974).

2. Effects of dissolution. Exposed polycystine tests are subjected to extensive dissolution both within the water column and as sediments accumulating on the seafloor. Dissolution is greatest near the surface and decreases with depth, a pattern reflecting bathymetric distribution of dissolved silicon and reduced temperature (Berger, 1968). In modern oceans, dissolution affects delicate forms composed of thinner elements first (Berger, 1968), thus biasing the fauna in favour of deep-living forms with more robust skeletons. Most tests reaching the bottom do so encapsulated in fecal pellets (Adelseck and Berger, 1975) and thus would be less affected by dissolution.

3. Differential preservation. Preservation is usually best in siliceous tests, but detail remains reasonably clear in many that are pyritized. Recrystallization obliterates most structural detail making positive identification impossible.

4. Sedimentary compaction, particularly in shale and mudstone, can destroy all but the sturdiest tests (Pessagno, 1976, p. 59).

Taxa are designated rare (1-2 specimens), common (3-6 specimens) or abundant (>6 specimens). Where poor preservation prohibits positive identification, brief comments regarding the general character of the specimens are listed under sample number in Appendix 1.

Range charts illustrating the local range of all taxa were used to develop a zonation scheme for Radiolaria in the Queen Charlotte Islands using first and final appearances of abundant taxa to mark zonal boundaries. Well preserved ammonite suites were found in close association with most radiolarian assemblages, providing excellent biostratigraphic control. In intervals lacking ammonites, microassemblages were dated by comparison with other radiolarian faunas of known age. Where neither of the above means could be used (e.g., Fannin Formation at Fannin Bay, Maude Island), tentative ages were based on lithological correlation. The beds at Fannin Bay and in stratigraphic section 4 are close geographically and the lithology is so distinctive that we are quite confident about the correlation of these beds.

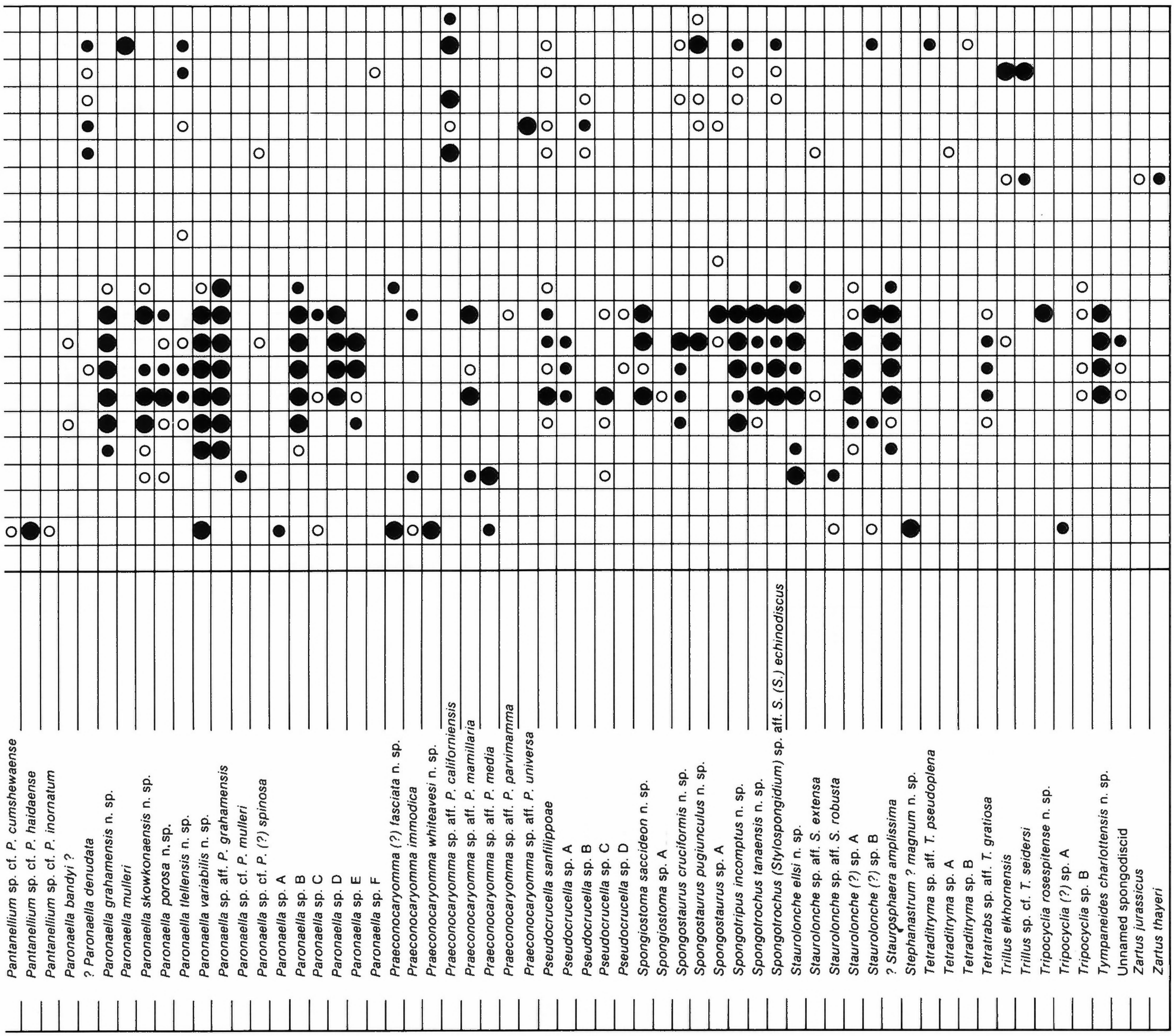
○ RARE (1 to 2 specimens)

● COMMON (3 to 6 specimens)

⬤ ABUNDANT (>6 specimens)

	LOWER JURASSIC										MIDDLE JURASSIC										
STAGE and SUBSTAGE	upper Pliens. to lower Toarcian			TOARCIAN						AALENIAN	BAJOCIAN										
				middle	upper middle to lower upper				upper		lower										
GROUP	MAUDE										YAKOUN										
FORMATION	FANNIN			WHITEAVES	PHANTOM CREEK						GRAHAM ISLAND										
INFORMAL RADIOLARIAN ZONES	1			2	3	4				5	6	7									
SAMPLES	C-080578	C-080577	C-080580	C-080579	C-080581	C-080582	C-080583	C-080584	C-080585	C-080597	C-080586	C-080589	C-080590	C-080591	C-080592	C-080587	C-080588	C-080593	C-080594	C-080595	C-080596
Acaeniotyle (?) ghostensis n. sp.							●	●	○	●											
Acaeniotyle (?) sp. A		⬤																			
Acaeniotyle (?) sp. B										○											
Alievium ? juskatlaensis n. sp.						○	○		⬤	⬤											
Amphibrachium (?) phantomensis n. sp.					○	●	●	●	●	●											
Caltrop nodosum n. sp.						○	○	○	●												
Crucella angulosa n. sp.		●		○		●	⬤	⬤	⬤												
Crucella sp. aff. *C squama*		○				●	●	⬤	⬤	●											
Crucella sp. A											●							○	○		
Emiluvia acantha n. sp.																	●	●	○	○	○
? Emiluvia antigua												●				○			○		
Emiluvia (?) moresbyensis n. sp.				⬤			○	●	○	●											
Emiluvia oldmassetensis n. sp.																			●	●	
Emiluvia splendida n. sp.																				⬤	
Emiluvia sp. aff. *E. pessagnoi*																	⬤			⬤	
Emiluvia (?) sp. A				●				○													
Emiluvia (?) sp. B				●																	
Emiluvia sp. C				●																	
Emiluvia sp. D							○	○		○											
Emiluvia sp. E												●				○	⬤				
Gorgansium silviesensis													●								
Hagiastrum sp. cf. *H. egregium*					⬤	⬤	⬤	●	●	⬤	⬤										
Hagiastrum sp. A		⬤																			
? Heliodiscus inchoatus							○			⬤											
Higumastra sp. A										○										⬤	
Homeoparonaella reciproca n. sp.				○		⬤	⬤	⬤	⬤												
Homeoparonaella sp. aff. *H. argolidensis*					○	⬤	●	●	○		○										
Homeoparonaella sp. aff. *H. elegans*									○							○	●				
Mesosaturnalis hexagonus							●	●	●	○	●										
Mesosaturnalis sp. cf. *M. septispinus*								○													
Orbiculiforma kwunaensis n. sp.		⬤																			
Orbiculiforma trispinula n. sp.		●																			
Orbiculiforma sp. aff. *O. persenex*							○														
Orbiculiforma sp. A		⬤	○																		

Figure 4. *Distribution and relative abundance of Spumellaria.*



Pantanellium sp. cf. P. cumshewaense
Pantanellium sp. cf. P. haidaense
Pantanellium sp. cf. P. inornatum
Paronaella bandyi ?
? Paronaella denudata
Paronaella grahamensis n. sp.
Paronaella mulleri
Paronaella skowkonaensis n. sp.
Paronaella porosa n.sp.
Paronaella tlellensis n. sp.
Paronaella variabilis n. sp.
Paronaella sp. aff. P. grahamensis
Paronaella sp. cf. P. mulleri
Paronaella sp. cf. P. (?) spinosa
Paronaella sp. A
Paronaella sp. B
Paronaella sp. C
Paronaella sp. D
Paronaella sp. E
Paronaella sp. F
Praeconocaryomma (?) fasciata n. sp.
Praeconocaryomma immodica
Praeconocaryomma whiteavesi n. sp.
Praeconocaryomma sp. aff. P. californiensis
Praeconocaryomma sp. aff. P. mamillaria
Praeconocaryomma sp. aff. P. media
Praeconocaryomma sp. aff. P. parvimamma
Praeconocaryomma sp. aff. P. universa
Pseudocrucella sanfilippoae
Pseudocrucella sp. A
Pseudocrucella sp. B
Pseudocrucella sp. C
Pseudocrucella sp. D
Spongiostoma saccideon n. sp.
Spongiostoma sp. A
Spongostaurus cruciformis n. sp.
Spongostaurus pugiunculus n. sp.
Spongostaurus sp. A
Spongotripus incomptus n. sp.
Spongotrochus tanaensis n. sp.
Spongotrochus (Stylospongidium) sp. aff. S. (S.) echinodiscus
Stauroloriche ellisi n. sp.
Staurolonche sp. aff. S. extensa
Staurolonche sp. aff. S. robusta
Staurolonche (?) sp. A
Staurolonche (?) sp. B
? Staurosphaera amplissima
Stephanastrum ? magnum n. sp.
Tetraditryma sp. aff. T. pseudoplena
Tetraditryma sp. A
Tetraditryma sp. B
Tetratrabs sp. aff. T. gratiosa
Trillus elkhornensis
Trillus sp. cf. T. seidersi
Tripocyclia rosespitense n. sp.
Tripocyclia (?) sp. A
Tripocyclia sp. B
Tympaneides charlottensis n. sp.
Unnamed spongodiscid
Zartus jurassicus
Zartus thayeri

○ RARE (1 to 2 specimens)

• COMMON (3 to 6 specimens)

● ABUNDANT (>6 specimens)

	C-080578	C-080577	C-080580	C-080579	C-080581	C-080582	C-080583	C-080584	C-080585	C-080597	C-080586	C-080589	C-080590	C-080591	C-080592	C-080587	C-080588	C-080593	C-080594	C-080595	C-080596
	LOWER JURASSIC											MIDDLE JURASSIC									
STAGE and SUBSTAGE	upper Pliens. to lower Toarcian			TOARCIAN							AALENIAN	BAJOCIAN									
				middle	upper middle to lower upper					upper		lower									
GROUP	MAUDE											YAKOUN									
FORMATION	FANNIN			WHITEAVES	PHANTOM CREEK							GRAHAM ISLAND									
INFORMAL RADIOLARIAN ZONES	1			2	3	4				5	6	7									
Archeodictyomitra sp. aff. *A. primagena*				○																	
Bipedis fannini n. sp.		○																			
Canoptum anulatum				●																	
Canoptum sp. cf. *C. dixoni*		○	○				○			•											
Canoptum (?) sp. A		●		○						○											
Canutus nitidus		●																			
Canutus giganteus		●																			
Canutus hainaensis		•																			
Canutus izeensis		○																			
Canutus tipperi		•																			
Canutus sp. aff. *C. nitidus*		●																			
Canutus sp. A		•																			
Droltus sp. cf. *D. lyellensis*		○																			
Droltus sp. A																		○			
Elodium cameroni n. sp.					●	●	●	●	●	●	○										
Elodium nadenensis n. sp.					●	○	●	•		●	●										
Elodium (?) sp. A					○			○		○											
Eucyrtidiellum sp. aff. *E. unumaensis*				•										○							
Eucyrtidium elementarius n. sp.				?							○							○	●	●	
Eucyrtidium (?) sp. A															○		○			?	
Hsuum mulleri ?				○																	
Hsuum optimus n. sp.				●	●	•	●	●	●	●	●										
Hsuum sp. aff. *H. belliatulum*											•						○		○		
Hsuum sp. cf. *H. mirabundum*																○		○	○	●	
Hsuum sp. aff. *H. mirabundum*																	•			●	

Figure 5. *Distribution and relative abundance of Nassellaria.*

Hsuum sp. cf. *H. rosebudense*				●																	
Hsuum sp. A				•																	
Hsuum sp. B				●			○	○		●											
Hsuum (?) sp. C										?								○	○		
Jacus magnificus n. sp.		○		●																	
Jacus sp. A				●																	
Katroma ninstintsi n. sp.		●	○																		
Lithomelissa sp. A										○											
Drulanta edenshawi n. sp.	○	●																	?		
Crubus wilsonensis n. sp.				●														?			
Lupherium sp. A				•						○		○								○	
Lupherium (?) sp. B				●		●	●	●	●	●											
Maudia yakounense n. sp.						○	•	•	•												
Mita sp. A.																		○	○	○	
Napora browni							○														
Napora horrida																○	○				
Napora insolita								○													
Napora turgida								○	○												
Napora sp. aff. *N. cosmica*							•	•													
Napora sp. aff. *N. turgida*		○		•	•		•	○	○												
Parvicingula aculeata n. sp.				•				○		○	○	•		○		○	○	○	●	●	
Parvicingula boesii group				●								○					○		•	○	
Parvicingula matura							?					○			•		●	●	●	●	
Parvicingula sp. aff. *P. burnensis*				○						•							○	○	●		
Parvicingula sp. aff. *P. media*				●							○	○				○			•	●	
Parvicingula sp. aff. *P. profunda*													○				○	•		•	
Parvicingula (?) sp. A				●																	
Parvicingula sp. B												○			○	○		•	●	●	
Parvicingula sp. C															○		○		○	○	
Parvicingula sp. D											○								○	•	
Parvicingula sp. E				●																	
Parvicingula sp. F.															○				○		
Protoperispyridium hippaensis n. sp.				●						○		○					•	○		●	
Perispyridium ? sp. A				○				○													
Perispyridium sp. B												○						•	○	●	
Protounuma paulsmithi n. sp.				●						○											
Poulpus (?) sp.		○																			
Rolumbus kiustaense n. sp.						○	●	○	○												
Stichocapsa sp. cf. *S. convexa*				●								•	○		○		○	•	●	●	○
Stichocapsa sp. aff. *S. japonica*												•			○		○	•	•	●	
Tricolocapsa (?) fusiformis																			○		
Tricolocapsa sp. cf. *T. rusti*				●						•	•	●	●	●	●	●	●	●	●	●	
Turanta morinae					○	○	○		○	•	○										
Turanta nodosa							○														
Turanta sp. A						•	○	○													
Wrangellium oregonense		•		○																	
Genus A, undet.				●							•	•		○				●	●	●	
algal cyst																					
Lophodictyotidium sp. cf. *L. sarjeanti*												●	●	●	●	●	●				

BIOSTRATIGRAPHY

Integration of ammonite, foraminiferal and radiolarian data

The recognition of the age significance of Queen Charlotte radiolarian material, as stated previously, is based on associated ammonites, foraminifers and, to a lesser degree, on comparison with other radiolarian assemblages from western North America. Ammonites are referred to North American ammonite zones from the Pliensbachian (Smith et al., in press) and the Bajocian (Hall and Westermann, 1980). Toarcian ammonite sequences are provisionally compared with the Northwest European succession (Dean, Donovan and Howarth, 1961) until work in progress culminates in a North American zonal scheme for the Toarcian. North American ammonite sequences have more in common with the Tethyan rather than the Boreal Realm, to which the Northwest European Province belongs. Foraminiferal faunas also suggest a Tethyan aspect but cosmopolitan species compare well with those of the Northwest European Province. Early Jurassic foraminifers have been recorded very rarely in North America, the exception being northern Alaska (Tappan, 1955). The Alaskan material is distinctly Boreal, however, and does not compare well with the Queen Charlotte Islands' microfaunas.

Late Pliensbachian

Two samples from a creek just west of Fannin Bay, Maude Island (GSC localities C-080577 and C-080578; Fig. 6; stratigraphic section 4 of Cameron and Tipper, 1985), were collected from a silty, sandy limestone of the Fannin Formation. No associated macrofossils were found at these localities, but the lithologically distinctive chamosite beds indicate a close correlation with similar beds outcropping on the adjacent beach. At the latter locality (stratigraphic section 6 of Cameron and Tipper, 1985), the chamosite beds yield an ammonoid fauna (dominated by *Tiltoniceras propinquum*) that is characteristic of the uppermost Pliensbachian in North America.

At another locality of the Fannin Formation, GSC sample C-080580 was collected from calcareous sandstone three metres stratigraphically below middle Toarcian grey shales and just above known upper Pliensbachian rocks, (Fig. 6; stratigraphic section 10 of Cameron and Tipper, 1985).

By far the richest and most diverse radiolarian assemblage occurs in the sample from GSC locality C-080577 on Maude Island. Well over 50 species are present in that sample, many of which have not been previously described. Comparison with known taxa from other areas favours a late Pliensbachian age. Numerous species described by Pessagno and Whalen (1982) are present, including *Canutus giganteus*, *C. hainaensis*, *C. izeensis* and *C. tipperi* sp. A, none of which is presently known to range above the upper Pliensbachian.

Foraminiferal faunas of the Fannin Formation are less diverse than either the underlying lower Pliensbachian rocks or the overlying Toarcian units. This is probably due to the shallower depositional environment of the Fannin Formation. The lower part of the Fannin Formation carries forms that are generally compatible with a late Pliensbachian age in Europe. These include *Nodosaria metensis*, *N.* sp. cf. *N. radiata*, *N.* sp. cf. *N. multicostata*, *Marginulina prima prima*, *M. prima burgundiae*, *Lenticulina* sp. cf. *L. polygonata*, *Falsopalmula* sp. cf. *F. crassecostata* and the highest occurrence in the area of the *Geinitzinita tenera* plexus. Higher parts of the Fannin Formation appear to represent quite shallow environments indeed, where agglutinating forms predominated. These faunas include species of *Ammobaculites*, *Reophax*, *Ammodiscus*, *Haplophragmoides* and *Trochammina*, some of which appear to have at least local biostratigraphic value.

Middle Toarcian

The concretionary shale member of the Whiteaves Formation is a recessive, grey shale with abundant limestone nodules and concretions. Most of these limestone bodies have yielded no radiolarians, with one important exception. Limestone nodules collected from a small creek bed just above Fannin Bay, Maude Island (GSC locality C-080579) have produced a rich and varied, pyritized radiolarian assemblage. From this locality (Fig. 6; stratigraphic section 6 of Cameron and Tipper, 1985) a single ammonite has been identified as a species of *Phymatoceras* and may be equivalent to the early middle Toarcian Bifrons Zone[1] (H.W. Tipper, pers. comm., 1984). Other ammonites tentatively identified as *Hildoceras*, *Hildoceratoides* and *Peronoceras*, are found in association with *Phymatoceras* at other localities in rocks of similar lithology.

As far as the authors are aware, this is the first well documented middle Toarcian radiolarian fauna in the world. Consequently, most forms in this large pyritized assemblage are either entirely new or have affinities with taxa found stratigraphically higher. Thus, very few are known Toarcian age indicators. Of the Toarcian marker taxa proposed by Pessagno et al. (1987, see Textfig. 5), *Canoptum anulatum* Pessagno and Poisson is present and an ancestral form of *Perispyridium* has its first appearance (see *Protoperispyridium hippaensis* n. sp. and *Perispyridium* (?) sp. A, in this report). Although not included in this report, the presence of *Praeconocaryomma parvimamma* Pessagno and Poisson cannot be completely ruled out, as pyrite overgrowths obscure the delicate meshwork of many praeconocaryommids, making them extremely difficult to identify. A form almost identical to *Lupherium* sp. A of Pessagno and Whalen (1982) from Pliensbachian radiolarian cherts of the Franciscan Complex in California, is common in the present collections, and extends in reduced numbers into the early Bajocian.

The Whiteaves Formation carries a very large and diverse microfauna, including an abundance of *Lenticulina d'orbignyi*, a worldwide indicator of sediments of Toarcian age. Other very common species include *Falsopalmula varians*, *Lenticulina toarcense*, *L. prima* and *Pseudonodosaria* sp. Large and distinctive species of *Citharina* are a common component of most collections from the Whiteaves Formation. These include *C. clathrata*, *C. sagittiformis*, *C. colliezi* and *C.* sp. cf. *C. clausa*. Rotaloid foraminifers are somewhat less abundant and include species of *Reinholdella*

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[1] The use of the capitalized, unitalicized trivial name of the index species as an ammonite standard zone name is a long standing practice, which, although in contravention of the North American Stratigraphic Code and the guide of the International Subcommission on Stratigraphic Classification, was recently justified by Callomon (1984), and is used in this publication.

and *Conorboides*. Ostracodes, although commonly very abundant, are represented by only a few species. These collections are dominated by *Kinkelinella sermoisensis*, with more infrequent occurrences of *Monoceratina* and *Cytherella*, and appear to be good markers for the Toarcian.

Late middle to late Toarcian

Samples from the Yakoun River (Fig. 6; stratigraphic sections 11 and 12 of Cameron and Tipper, 1985) are from the coquinoid sandstone member of the Phantom Creek Formation. Stratigraphically, the strata in which the lowermost of these samples occur (GSC locality C-080581) also contain ammonites, compared tentatively to *Haugia*, *Haugiella* and *Denckmannia* (H.W. Tipper, pers. comm., 1984) and thus these strata are broadly correlative with the Variabilis Zone of late middle Toarcian age. All but one of the remaining samples are from higher in the Phantom Creek Formation and are associated with the ammonites *Haugia*, *Haugiella* and abundant *Hammatoceras* (a probable upper Toarcian species). The exact stratigraphic position of material from GSC locality C-080597 is uncertain. It was collected by H.W. Tipper in 1975 from the banks of the Yakoun River, before river floods carved out the excellent exposures now available. He believes it to be from the highest Toarcian beds on the river, above samples from GSC localities C-080581 through C-080585, but below strata containing *Esericeras*; thus to the best of our knowledge, it is probably of late Toarcian age.

There are few established radiolarian marker taxa known for the middle to late Toarcian; however, the rich fauna described in this report (including five new genera) promises a more precise subdivision of the interval. A late Toarcian age is established by the first appearance of *Parvicingula* s.l. Pessagno, *Turanta* Pessagno and Blome, specifically *T. morinae* Pessagno and Blome in a sample from GSC locality C-080581 and *T. nodosa* Pessagno and Blome in a sample from GSC locality C-080583. Less significant are *Trillus elkhornensis* Pessagno and Blome, and *Rolumbus* n. sp. (a genus newly established by Pessagno et al., 1986), whose presence suggests that the assemblage ranges from late Pliensbachian to late Toarcian in age.

Foraminifers associated with these radiolarian localities are as common and diverse as those of the underlying Whiteaves Formation. Several species with apparent biostratigraphic significance include *Citharina* sp. cf. *C. longemari*, *Lenticulina fovelata*, *Falsopalmula jurensis* and *Pseudonodosaria pygmaea*. *Lenticulina d'orbignyi*, a species abundant in the middle Toarcian Whiteaves Formation, is represented in the upper middle to upper Toarcian Phantom Creek Formation by a much more coarsely reticulate variety. Other localities of the lower Phantom Creek Formation have yielded several undescribed species of *Lenticulina* and *Marginulinopsis* as well as the ostracode *Kinkelinella*. Most of these species appear to have restricted stratigraphic ranges.

Aalenian

A single talus sample (GSC locality C-080586) was collected at a waterfall on Branch Road 59 on Graham Island (Fig. 6; stratigraphic section 13 of Cameron and Tipper, 1985) from a two metre thick calcareous sandstone. This sandstone is underlain by middle Toarcian grey shale and overlain paraconformably by lower Bajocian tuff, volcanic sandstone and shale. At this locality, this thin sandstone ledge represents a condensed sequence ranging in age from late middle Toarcian to Aalenian. The lower part of this sandstone contains *Esericeras*, *Haugia*, abundant *Hammatoceras* and a fragment of *Dumortieria*, this last specimen found in float. Upper parts of the sandstone, to which this sample compares best lithologically, have yielded *Hammatoceras* and *Tmetoceras* (H.W. Tipper, pers. comm., 1984). On this basis, together with the occurrence of abundant belemnites, the upper part of this sandstone is assigned to the belemnite sandstone member of the Phantom Creek Formation, and is Aalenian in age.

Radiolaria from these beds are less diverse than those from the middle and upper Toarcian. The combination of the presence of a few new forms and the absence of some of the previously occurring forms, however, make this assemblage reasonably distinctive. *Turanta morinae* Pessagno and Blome, a primary marker for the upper Aalenian ? (see Pessagno et al., 1987) is present, but its range in the Queen Charlotte Islands extends down to the upper middle Toarcian. No other microfauna has been recovered to date from beds containing known Aalenian ammonites.

Early Bajocian

All samples collected from the Branch Road 57 section and the Rennell Junction section (Fig. 6; stratigraphic sections 13 and 14 of Cameron and Tipper, 1985) are from the shale-tuff and volcanic sandstone members of the Graham Island Formation. With the exception of the sample from the volcanic sandstone member, all samples are associated with diverse but poorly preserved ammonites. On the whole, the ammonites suggest a correlation with the Northwest European Ovalis Zone and the lower part of the Laeviuscula Zone. In North America this biochronological interval encompasses the upper part of the *Docidoceras widebayense* Assemblage Zone and an unnamed interval subjacent to the *Parabigotites crassicostatus* Assemblage Zone (Hall and Westermann, 1980; Taylor, pers. comm., 1986).

Chlorophyte algal cysts (identified by Dr. G.E. Rouse of the University of British Columbia) are abundant in all lowest Bajocian samples. These are compared to *Lophodictyotidium sarjeanti* Pocock from Floral Zone $J2^2$ (late Bajocian) of Pocock (1972) and are known from the Shaunavon Formation, southern Saskatchewan, and the Sawtooth Formation, southern Alberta.

Lower Bajocian radiolarian marker taxa first appearing in these assemblages include *Gorgansium silviesensis* Pessagno and Blome, *Parvicingula matura* Pessagno and Whalen, *Zartus thayeri* Pessagno and Blome, and forms comparable to *Trillus seidersi* Pessagno and Blome and *Hsuum mirabundum* Pessagno and Whalen. *Perispyridium* and *Parvicingula* s.l., which occur rarely in middle to upper Toarcian rocks, are abundant in the lower Bajocian. Longer ranging taxa include *Trillus elkhornensis* Pessagno and Blome, and *Zartus jurassicus* Pessagno and Blome.

Foraminifers from lower Bajocian rocks are generally rare but have yielded what appear to be rather distinctive species. The shale-tuff member of the Graham Island Formation is recognizable by the occurrence of several distinctive, but as yet unidentified, species of *Lenticulina*, *Marginulina*, *Frondicularia* and *Marginulinopsis*. These beds have also yielded specimens of *Astacolus anceps* and *Ammodiscus tolypa*. Higher in the section, the volcanic sandstone member is clearly a shallower water deposit whose rather meagre foraminiferal fauna consists entirely of agglutinating forms. Several genera are represented,

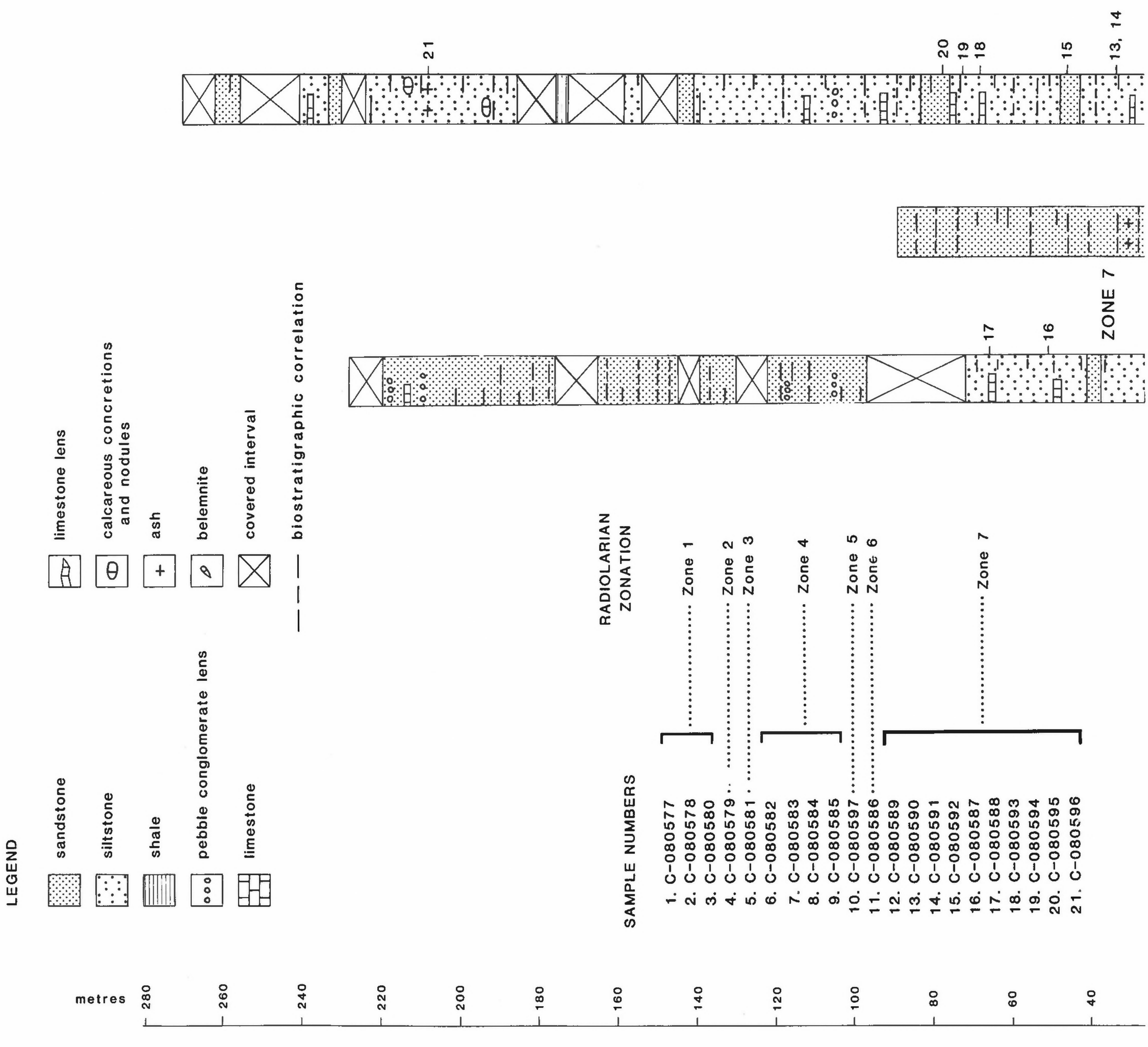
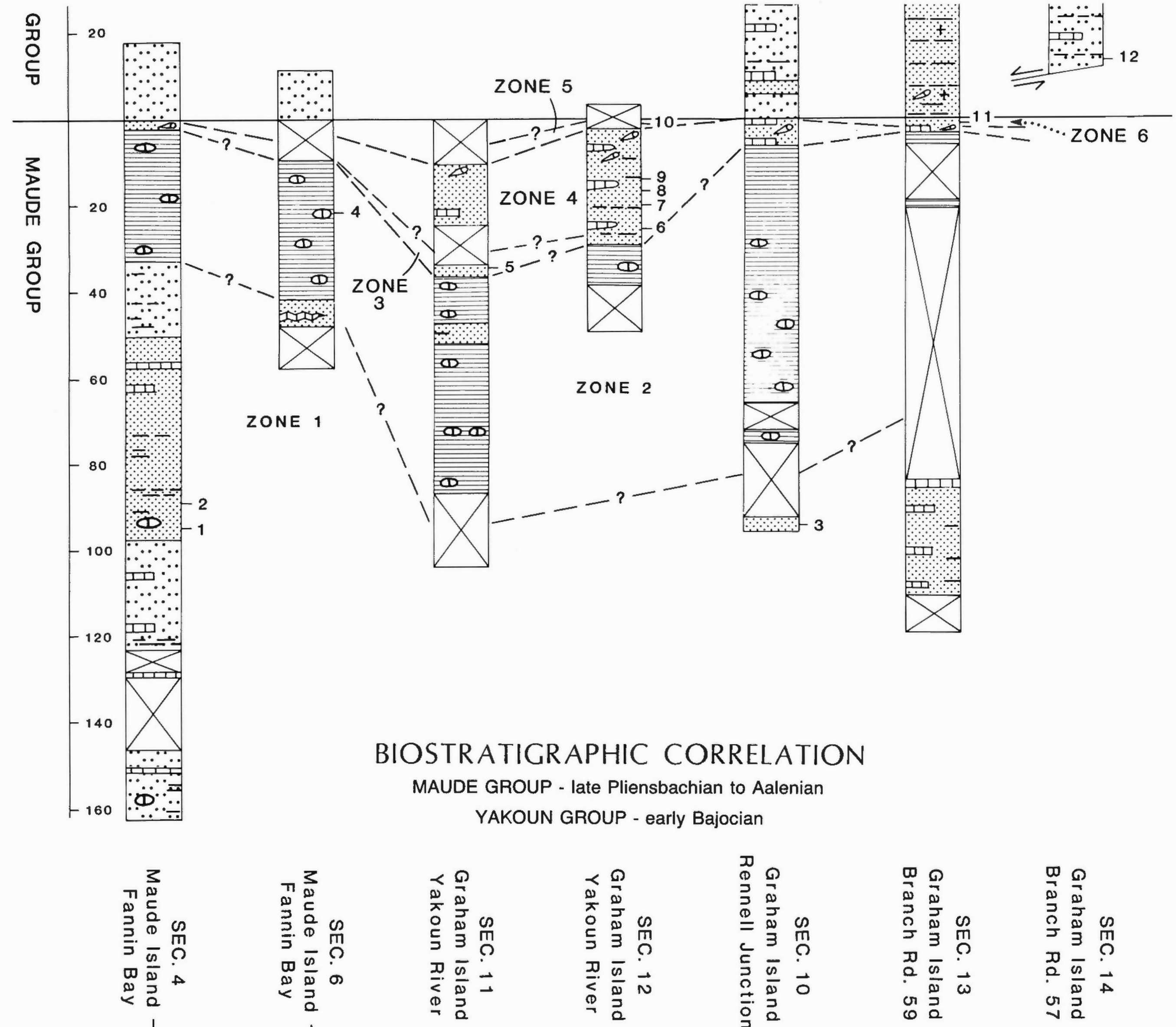


Figure 6. *Biostratigraphic correlation of sections, showing GSC sample localities and radiolarian zonal correlation. Stratigraphic sections modified from Cameron and Tipper, 1985.*



BIOSTRATIGRAPHIC CORRELATION

MAUDE GROUP - late Pliensbachian to Aalenian

YAKOUN GROUP - early Bajocian

however, including *Bigenerina, Ammobaculites, Reophax, Trochammina* and ?*Trochamminoides*. Further work with these microfaunas should enable those of biostratigraphic value to be determined.

Biostratigraphic correlation

The Pliensbachian to lower Bajocian sections exposed on the Queen Charlotte Islands are in many cases fault bounded, and frequently incompletely exposed. A further complication is that not all of the limestones sampled yielded radiolarians, so there are essentially barren intervals within individual sections. As a result, with only minor exceptions, zonal boundaries are drawn arbitrarily within these barren intervals and between localities resulting in a poor definition of the stratigraphic top and base of a particular zone. From the material presently available, seven radiolarian zones have been recognized within rocks of the Fannin, Whiteaves, Phantom Creek and Graham Island formations.

At present, all rocks of the Fannin Formation (Fig. 6) are confined to Zone 1. Only one sample from the Whiteaves Formation has yielded radiolarians; this was from the upper part of the concretionary shale member on Maude Island. Until further information is available, all the Whiteaves Formation is placed in Zone 2, a large stratigraphic interval with poorly defined radiolarian zonal boundaries. On the Yakoun River, the lower, or septarian shale, member is thicker than the same unit in the Skidegate Inlet area, but contains few limestones, from which no radiolarians have been recovered. Two distinct foraminiferal assemblages have been obtained from the lower member in addition to one from the upper member. This indicates hope for further radiolarian refinement in the future as more material becomes available. Sampling of Toarcian calcareous sandstones, up to but not including the Aalenian belemnite sandstone on the Yakoun River, has yielded extremely diverse and continuous assemblages of Radiolaria, thus enabling the recognition of three zones (3 through 5). The very thin, uppermost sandstone sampled on Branch Road 59 carries a fairly rich and distinct microfauna, which is assigned to Zone 6. Lower Bajocian rocks of the Graham Island Formation contain radiolarians that are, in general, distinct from those of older rocks, and all, up to the highest interval sampled (GSC locality C-080596), are included in Zone 7.

Radiolarian zonation

A radiolarian zonation is proposed herein for upper Pliensbachian to lower Bajocian strata in the Queen Charlotte Islands. The emphasis is primarily on the Toarcian because it has not been studied in detail elsewhere, and Toarcian assemblages from the Queen Charlotte Islands are exceedingly diverse and include many new taxa.

Seven informal radiolarian zones are distinguished (Fig. 7). Zone 1 is late Pliensbachian. Zones 2, 3, 4, and 5 are middle to late Toarcian. Zone 6 (Aalenian) is essentially a transition zone marking the gradual change between Toarcian and Bajocian faunas. Zone 7 is early Bajocian.

This is a local zonation that has not yet been tested in other areas to determine gaps, overlaps, areas of collection failure, preservation failure and so forth. Testing and

Chronostratigraphic Units			STANDARD AMMONITE ZONES Northwest Europe	AMMONITE ZONES Western North America		RADIOLARIAN ZONES
MIDDLE JURASSIC	early Bajocian		SAUZEI	CRASSICOSTATUS		
			LAEVIUSCULA			7
			OVALIS	WIDEBAYENSE (Alaska)		
			DISCITES			
	Aalenian		CONCAVUM	HOWELLI		
			MURCHISONAE			
			SCISSUM			?
			OPALINUM			6
EARLY JURASSIC	Toarcian	late	LEVESQUEI	Presently under study		
			THOUARSENSE			5
		middle	VARIABILIS			4
						3
			BIFRONS			2
		early	FALCIFER			
			TENUICOSTATUM			
	late Pliens.		SPINATUM	CARLOTTENSE	PROPINQUUM	1
			MARGARITATUS		KUNAE	

Figure 7. Proposed radiolarian zonation. Northwest European ammonite zones after Dean, Donovan and Howarth (1961). Ammonite zones for western North America after Hall and Westermann (1980), Smith et al. (in press). Radiolarian zones 2 to 6 show a broad correlation with northwest European ammonite zones, but the precise correlation of boundaries is not implied.

evaluation of these zones will continue as more information becomes available from Toarcian localities elsewhere. Formal names may then be applied to these zones.

In this report, zonal units are either Oppel zones (= concurrent range zones of the International Subcommission on Stratigraphic Classification [ISSC], Hedberg, 1976, p. 55, 57) or interval zones. According to the ISSC (Hedberg, 1976) Oppel zones are "characterized by having more than two taxa, and having boundaries based on two or more documented first and/or last occurrences of the included characterizing taxa". Interval zones are defined by The North American Commission on Stratigraphic Nomenclature (1983, p. 863), as "the body of strata between two specified, documented lowest and/or highest occurrences of single taxa". The type of zonal terminology, local range zones and abundance zones are indicated in Figure 8. It should be noted that Zones 1 and 7 are incompletely defined at present, that is, the base of Zone 1 is undefined; the top of Zone 7 is undefined.

Discussion of individual zones focuses on abundant taxa, but includes rarer forms where there are grounds for believing them to be significant, such as those that are useful in other regions. Marker taxa have been chosen with the following criteria in mind: they should 1) be distinctive; 2) have sturdy tests (that can be preserved in a variety of rock types); and 3) identification should be possible with a good quality binocular microscope.

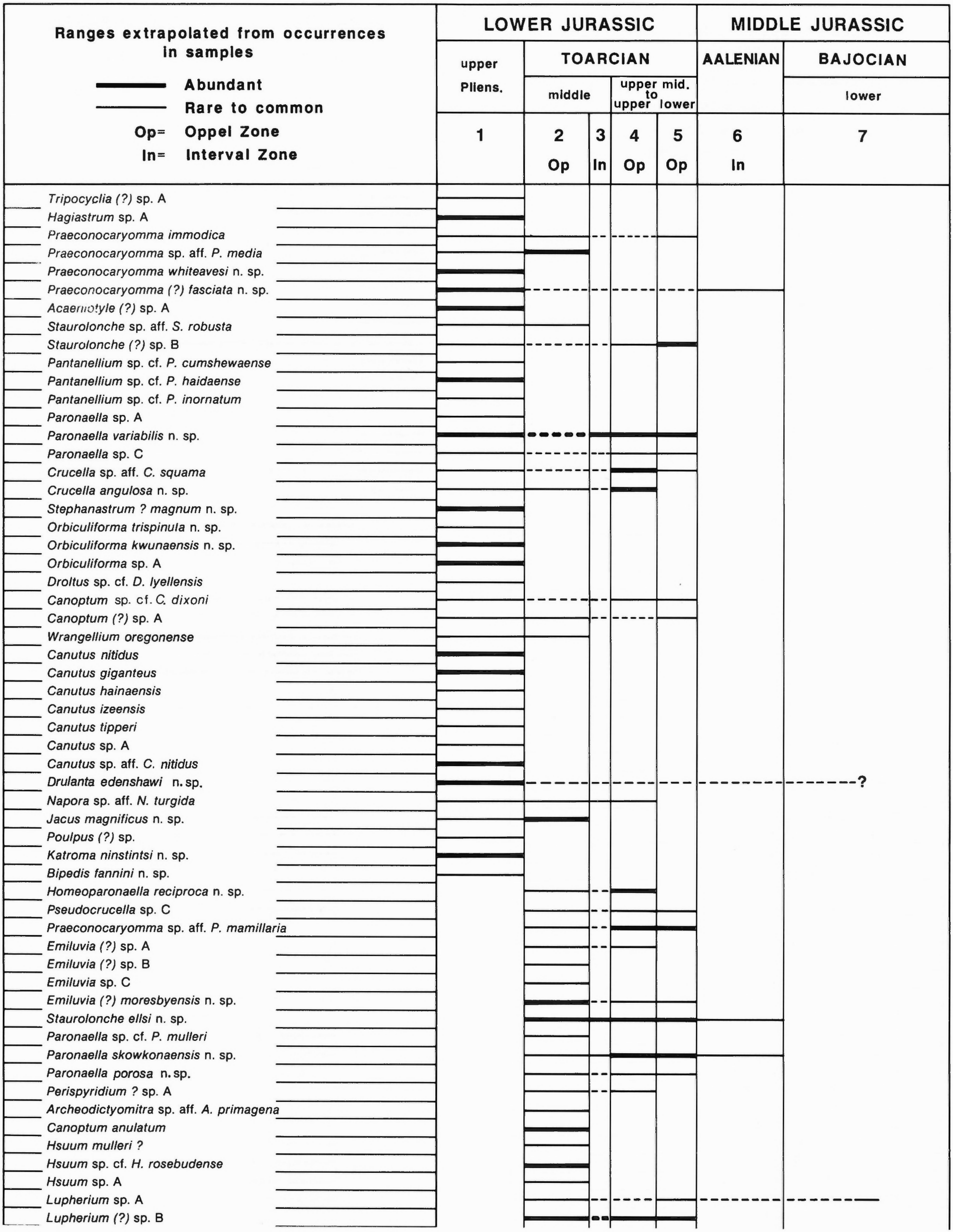


Figure 8. *Biostratigraphic distribution of all radiolarian taxa.*

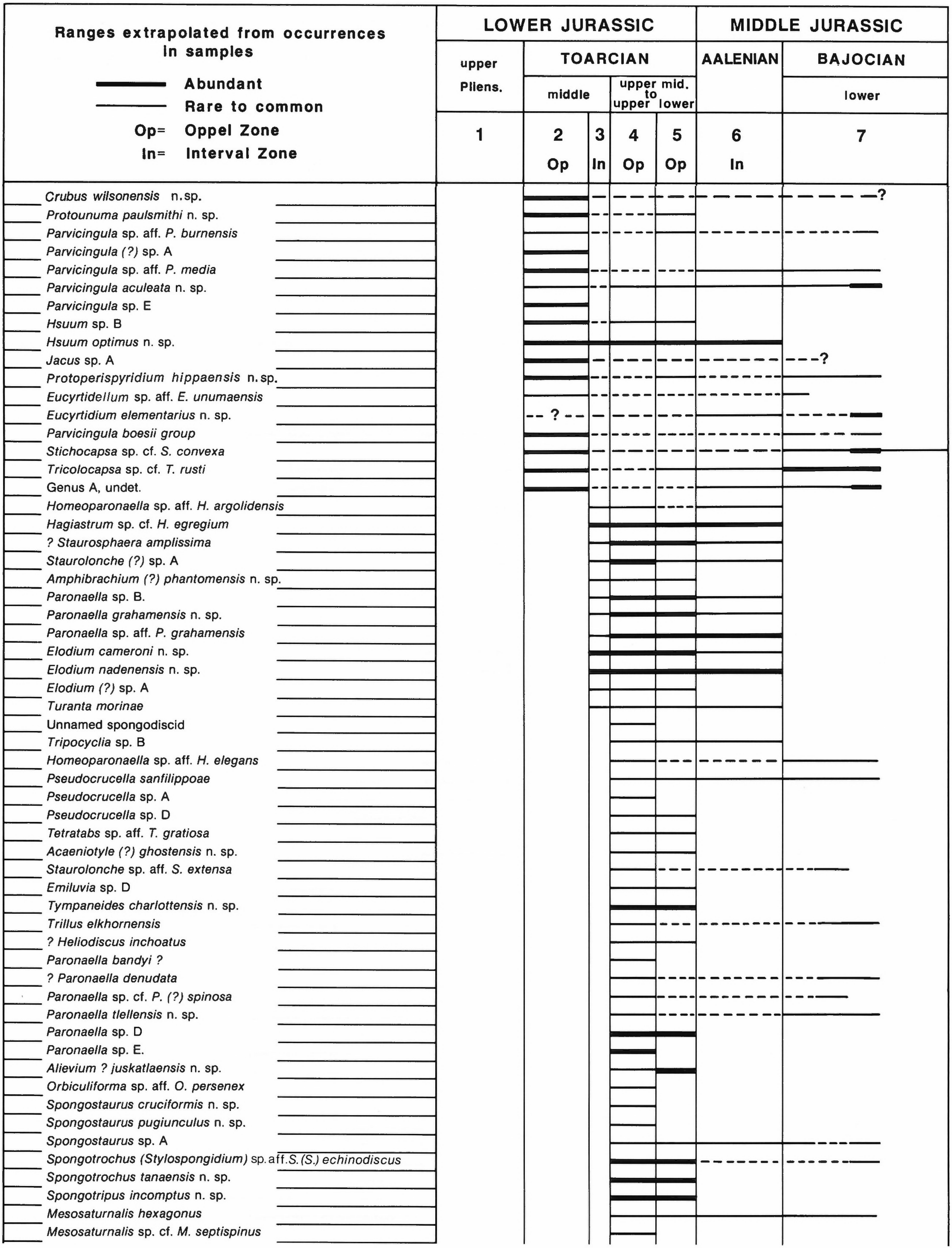
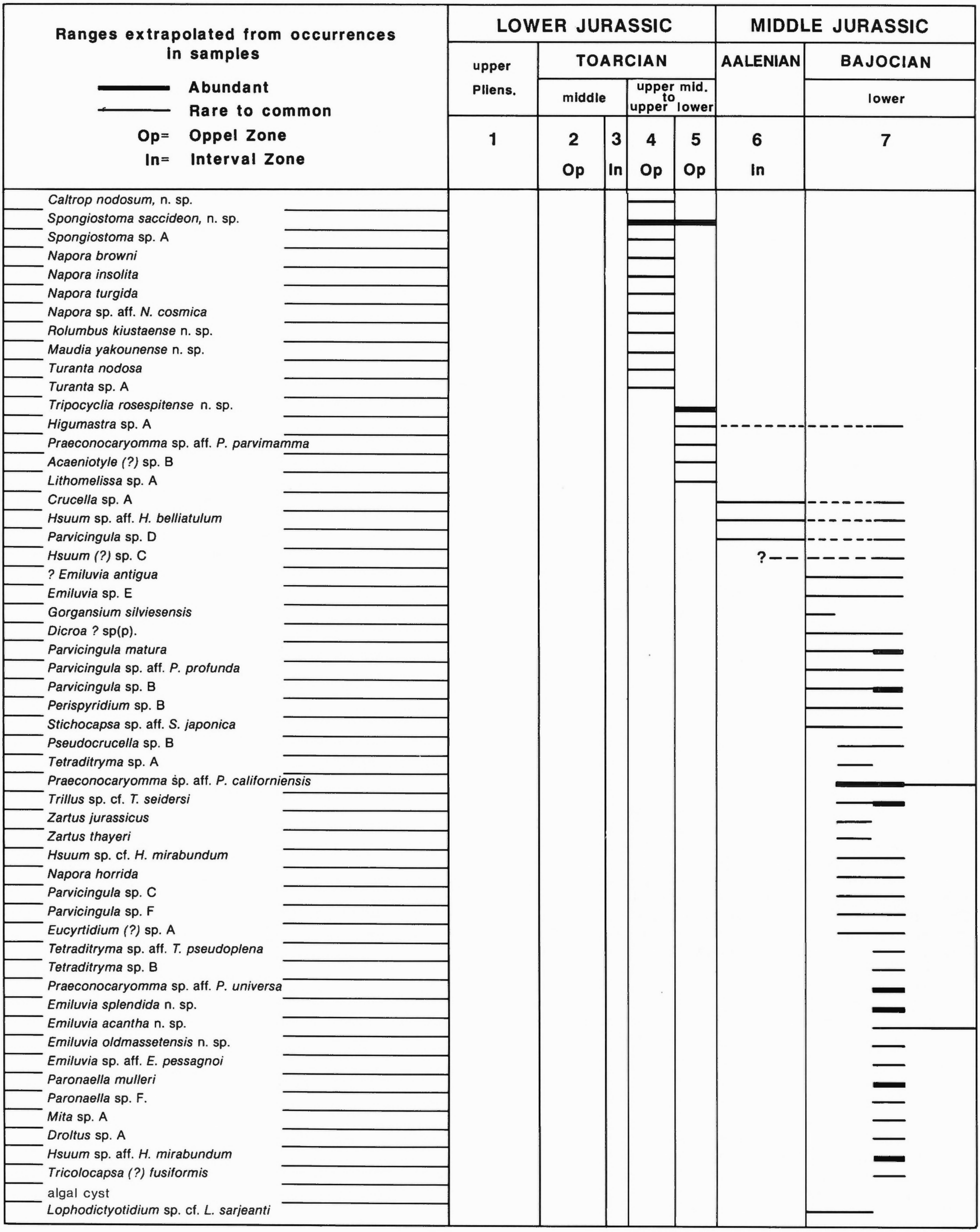


Figure 8. cont'd.


Ranges extrapolated from occurrences in samples
Abundant
Rare to common
Op= Oppel Zone
In= Interval Zone
LOWER JURASSIC
MIDDLE JURASSIC
upper Pliens.
TOARCIAN
AALENIAN
BAJOCIAN
middle
upper mid. to upper lower
lower
1
2 Op
3 In
4 Op
5 Op
6 In
7
Caltrop nodosum, n. sp.
Spongiostoma saccideon, n. sp.
Spongiostoma sp. A
Napora browni
Napora insolita
Napora turgida
Napora sp. aff. N. cosmica
Rolumbus kiustaense n. sp.
Maudia yakounense n. sp.
Turanta nodosa
Turanta sp. A
Tripocyclia rosespitense n. sp.
Higumastra sp. A
Praeconocaryomma sp. aff. P. parvimamma
Acaeniotyle (?) sp. B
Lithomelissa sp. A
Crucella sp. A
Hsuum sp. aff. H. belliatulum
Parvicingula sp. D
Hsuum (?) sp. C
? Emiluvia antigua
Emiluvia sp. E
Gorgansium silviesensis
Dicroa ? sp(p).
Parvicingula matura
Parvicingula sp. aff. P. profunda
Parvicingula sp. B
Perispyridium sp. B
Stichocapsa sp. aff. S. japonica
Pseudocrucella sp. B
Tetraditryma sp. A
Praeconocaryomma sp. aff. P. californiensis
Trillus sp. cf. T. seidersi
Zartus jurassicus
Zartus thayeri
Hsuum sp. cf. H. mirabundum
Napora horrida
Parvicingula sp. C
Parvicingula sp. F
Eucyrtidium (?) sp. A
Tetraditryma sp. aff. T. pseudoplena
Tetraditryma sp. B
Praeconocaryomma sp. aff. P. universa
Emiluvia splendida n. sp.
Emiluvia acantha n. sp.
Emiluvia oldmassetensis n. sp.
Emiluvia sp. aff. E. pessagnoi
Paronaella mulleri
Paronaella sp. F.
Mita sp. A
Droltus sp. A
Hsuum sp. aff. H. mirabundum
Tricolocapsa (?) fusiformis
algal cyst
Lophodictyotidium sp. cf. L. sarjeanti
?

Zone 1

The base of Zone 1, at present, is undetermined. Radiolarian assemblages in this zone are generally similar to others of early late or late Pliensbachian age found lower in the sequence (not included in this report) and no significant first appearances of new taxa have been observed.

Abundant genera in this zone include *Canutus* Pessagno and Whalen, *Praeconocaryomma* Pessagno, *Katroma* De Wever, *Orbiculiforma* Pessagno and *Pantanellium* Pessagno. Several species of *Canutus*, including *Canutus tipperi* Pessagno and Whalen, are present; all range throughout the Pliensbachian. Before this report, Pessagno and Whalen (1982) confined the range of *C. tipperi* to early Pliensbachian, but specimens documented herein now enable the range of this species to be extended to the late Pliensbachian. Two new canutids are recognized: *Canutus* sp. aff. *C. nitidus* Yeh and *Canutus* sp. A. Less abundant taxa characteristic of this zone include *Bipedis* De Wever, *Canoptum* Pessagno, *Crucella* Pessagno, *Wrangellium* Pessagno and Whalen and, specifically, *Praeconocaryomma immodica* Pessagno and Poisson and a species compared to *Praeconocaryomma media* Pessagno and Poisson.

The top of the zone is characterized by the final appearance of *Katroma ninstintsi* n. sp., *Bipedis fannini* n. sp. and *Canutus* s.s. Pessagno et al. (1987) place this event within the early Toarcian, based on evidence from the Queen Charlotte Islands (Whiteaves Bay, south shore of Skidegate Inlet). Further study of the ammonites from this and other time-equivalent areas, has revealed the age to be late Pliensbachian rather than early Toarcian (Cameron and Tipper, 1985, p. 23). Thus, until radiolarians can be studied from more precisely dated lower Toarcian sediments, the extinction of *Canutus* s.s. must be placed at or near the top of Zone 1. Species characteristic of this zone are shown in Figure 8 and in Plates 1 to 3.

Zone 2

The base of Zone 2 is recognized by the first appearance of *Protoperispyridium* Yeh, *Parvicingula* Pessagno s.l. and *Emiluvia* Foreman. This well documented middle Toarcian radiolarian assemblage (approximately equivalent to the Bifrons Zone) is diverse and, for the most part, distinctly different from that of Zone 1. Over 30 species, many new, first appear in this zone. The assemblage is dominated by species of *Emiluvia* Foreman, *Hsuum* Pessagno, *Lupherium* Pessagno and Whalen, *Canoptum* Pessagno, and *Jacus* De Wever. Abundant species characteristic of this zone are *Protoperispyridium* (?) *hippaensis* n. sp., *Hsuum optimus* n. sp., *Protounuma paulsmithi* n. sp., *Emiluvia* (?) *moresbyensis* n. sp., *Jacus magnificus* n. sp., *Canoptum anulatum* Pessagno and Poisson, *Hsuum* sp. cf. *H. rosebudense* Pessagno and Whalen (this report) and forms assigned to *Parvicingula aculeata* n. sp., *Parvicingula* (?) sp. A and the *Parvicingula boesii* (Parona) group.

The top of Zone 2 is marked by the final appearance of *Jacus magnificus* n. sp. and *Parvicingula* (?) sp. A (this report). *Canoptum anulatum* Pessagno and Poisson ranges throughout the Toarcian according to Pessagno et al. (1987). In the Queen Charlotte Islands, however, it apparently does not range above the middle Toarcian (Zone 2) as it has not been recorded in any of the samples from Zones 3, 4 and 5 (late middle to late Toarcian), which have rich and extremely diverse faunas. Species characteristic of Zone 2 are shown in Figure 8 and in Plates 4 to 6.

Zone 3

This zone is defined on first appearances of species only; no significant extinctions are observed and no taxa are restricted exclusively to this interval.

The base of Zone 3 is recognized by the first appearance of *Turanta morinae* Pessagno and Blome, and *Elodium* n. gen. The bulk of the zone is characterized by the coincidence of a number of species of *Paronaella* Pessagno and by *Hsuum optimus* n. sp., *Elodium cameroni* n. sp., *Elodium nadenensis* n. sp. and a form compared to *Hagiastrum egregium* Rüst.

Species that make their first appearance in this zone are shown in Figure 8 and Plates 7, 8, and 11 to 13.

Zone 4

This zonal assemblage is the most diverse studied with over 65 species recorded; 38 make their first appearance in this zone. The assemblage is dominated by spumellarians, particularly the Hagiastridae Riedel and the Patulibracchiidae Pessagno. Some are similar to the Upper Jurassic taxa of Baumgartner (1980); for example, *Homeoparonaella argolidensis* Baumgartner, *Homeoparonaella elegans* (Pessagno), *Pseudocrucella sanfilippoae* (Pessagno), and *Tetratrabs gratiosa* Baumgartner.

The base of Zone 4 is recognized by the first appearance of *Tripocyclia* Pessagno s.s. and *Maudia* n. gen. Other genera first appearing at the base of this zone are *Caltrop* n. gen., *Spongiostoma* n. gen. and *Tympaneides* n. gen. Additional genera occurring in abundance include *Emiluvia* Foreman, *Staurolonche* Haeckel, *Hsuum* Pessagno, *Elodium* n. gen. and less distinctive spongy forms such as *Spongostaurus* Haeckel, *Spongotrochus* Haeckel, and *Spongotripus* Haeckel. *Paronaella bandyi* Pessagno and *Turanta nodosa* Pessagno and Blome first appear near the base of this zone, but are rare. Rare also are *Spongosaturnalis* (?) *hexagonus* Yao and a species compared to *Spongosaturnalis* (?) *septispinus* Yao; both taxa have now been reassigned to *Mesosaturnalis* following De Wever (1984).

The top of Zone 4 is marked by the final appearance of *Crucella angulosa* n. sp. and *Rolumbus kiustaense* n. sp.; current data indicate the latter may be confined to this zone. Other species that make their first or last appearance in this zone are shown in Figure 8 and in Plates 7 to 13.

Zone 5

This zone is characterized by the extinction of many species at the upper boundary, but the first appearance of only a few species at the base. As in Zone 4, spumellarians dominate the assemblage, particularly spongy forms such as *Paronaella* Pessagno, *Spongotrochus* Haeckel, *Spongotripus* Haeckel, *Spongostaurus* Haeckel and *Spongiostoma* n. gen.

The base of Zone 5 is recognized by the first appearance of *Higumastra* Baumgartner. Other abundant genera, which make up the bulk of the zone, are *Emiluvia* Foreman, *Hagiastrum* Haeckel, *Praeconocaryomma* Pessagno, *Hsuum* Pessagno and Whalen, and *Elodium* n. gen.

The top of Zone 5 is marked by the final appearance of *Canoptum* Pessagno s.s. and *Spongiostoma saccideon* n. sp.

(approximately equivalent to the top of Subzone $1A_2$ of Pessagno et al., 1987). Species that may make their final appearance at or near the top of this zone are shown in Figure 8 and Plates 7 to 14.

Zone 6

This assemblage is relatively small and illustrates the transition of radiolarians from the Toarcian to Bajocian. Many species from Zones 3, 4, and 5 make their last appearance in Zone 5; others range upward, becoming less abundant, disappearing at or near the top of Zone 6. Some characteristically middle Jurassic taxa first appear in this zone. More sampling and study of this stratigraphic interval is needed to improve resolution.

The base of Zone 6 is placed immediately above the final appearance of *Canoptum* Pessagno s.s.

The top of the zone is marked by the final appearance of *Turanta morinae* Pessagno and Blome, *Hsuum optimus* n. sp. and *Elodium* n. gen. (approximately equivalent to the top of Subzone $1A_1$ of Pessagno et al., 1987). Other species that make their first or final appearance in this zone are shown in Figure 8 and Plates 11 to 15.

Zone 7

The base of Zone 7 is recognized by the first appearance of *Parvicingula matura* Pessagno and Whalen and *Parvicingula* sp. B (this report). Auxiliary taxa appearing near the base of the zone include *Gorgansium silviesensis* Pessagno and Blome, *Zartus thayeri* Pessagno and Blome and forms comparable to *Trillus seidersi* Pessagno and Blome; *Emiluvia splendida* n. sp., *Emiluvia acantha* n. sp., and *Mita* sp. A (this report) are recorded somewhat higher in the zone. Zone 7 is characterized by the association of *Parvicingula* Pessagno, *Hsuum* Pessagno, *Perispyridium* Pessagno and Blome and *Emiluvia* Foreman, together with a number of smaller three- and four-chambered nassellarians (for example, *Tricolocapsa* Haeckel and *Stichocapsa* Haeckel); all are abundant.

The top of Zone 7 is undetermined, as no significant faunal extinctions are recognized. The uppermost sample (GSC locality C-080596) contains a very sparse fauna but all taxa are found lower in the zone. Although marker taxa differ, it is believed Zone 7 is approximately equivalent to the lower portion of Subzone 1B of Pessagno et al. (1987). Species appearing throughout this zone are shown in Figure 8 and Plates 4, 6, and 15 to 18.

Discussion

The proposed system of zonation is in general agreement with a preliminary radiolarian zonation for the Jurassic of North America proposed by Pessagno et al. (1987). Work herein confirms the final appearance of *Canoptum* Pessagno s.s. at or near the Toarcian - Aalenian boundary and the final appearance of *Turanta morinae* Pessagno and Blome at or near the Aalenian - Bajocian boundary. Deviations from the zonation of Pessagno et al. (1987) include:

1. An extended range for species such as *Canutus tipperi* Pessagno and Whalen.

2. The age of the chamosite beds on Maude Island (containing *Tiltoniceras propinquum*) is now considered to be Pliensbachian (Smith et al., in press); this conclusion can now be confirmed by data based on the radiolarians and foraminifers.

3. The first appearance, in the middle Toarcian (approximately equivalent to the Bifrons Zone) of *Protoperispyridium* Yeh, *Parvicingula* Pessagno s.l., and *Emiluvia* Foreman. Although some forms may be ancestral, their sheer abundance in Zone 2 suggests that they should not be ignored.

4. The first appearance of *Turanta* Pessagno and Blome in the late middle Toarcian (Zone 3) and *Parvicingula matura* Pessagno and Whalen in the Bajocian. Current evidence suggests that both events occur higher in the Queen Charlotte sequence than is generally recognized by Pessagno et al. (1987).

5. *Napora fructuosa* Pessagno, Whalen and Yeh and *Perispyridium tamarackense* Pessagno and Blome have not yet been recognized in Queen Charlotte assemblages, although some poorly preserved specimens from Zone 4 may be the latter.

6. *Zartus jurassicus* Pessagno and Blome does not appear until the Bajocian. This is unquestionably linked to the lack of pantanelliids in Toarcian samples, a subject discussed in the next section.

PALEOBIOGEOGRAPHY

Jurassic faunas in the Queen Charlotte Islands are allied to the Tethyan Realm. The ammonite fauna is very diverse and more closely related to the faunas of the conterminous United States, southern Europe, North Africa and South America than to those of northern Europe and cratonic North America, for example the Fernie Basin of southeastern British Columbia, and the Arctic (Smith and Tipper, 1986; Taylor et al., 1984). Radiolarians are also diverse, demonstrating affinity with Tethyan assemblages from California (Franciscan Complex) and east-central Oregon (Pessagno and Blome, 1980; Pessagno and Whalen, 1982), from Greece, Turkey and other Mediterranean areas (Baumgartner, 1980; Baumgartner, De Wever and Kocher, 1980; De Wever, 1981a-c, 1982; Pessagno and Poisson, 1981), and from Japan (Yao, 1972, 1979, 1982; Yao et al., 1980; Yao and Matsuoka, 1981).

This Tethyan association is perhaps most apparent among the Hagiastridae Riedel, 1971 and Patulibracchiidae Pessagno, 1971, sensu Baumgartner (1980). Toarcian assemblages abound with representatives of these families, (see "Systematic Paleontology"). In addition to these, many other species have not been dealt with here because they are represented by only one or two indifferently preserved specimens. A number of species compare with Upper Jurassic hagiastrids from Greece and Turkey (Baumgartner, 1980), which occur as early as the Toarcian; others are similar to patulibracchiids, such as species of *Paronaella* Pessagno and *Crucella* Pessagno, described by De Wever (1981b) from the Lower Jurassic of Turkey. Apart from the hagiastrids, some Pliensbachian forms from the Queen Charlotte Islands are closely related to the Tethyan species *Katroma neagui* Pessagno and Poisson and *Pantanellium* *inornatum* Pessagno and Poisson, both also from Turkey. Another form generally regarded as Tethyan is the genus *Acanthocircus* Squinabol (Pessagno, pers. comm., 1983). Two species of this genus (now assigned to *Mesosaturnalis* Kozur and Mostler, emend. De Wever) are found in the Toarcian and Bajocian assemblages from the Queen Charlotte Islands. The rarity of *Acanthocircus*, and the apparent lack of pantanelliids from the Toarcian of the Queen Charlotte Islands is problematical. It could either be due to a Boreal influence or, more probably, these delicate tests are destroyed during processing; all the Toarcian limestones processed are very coarse grained. Other Tethyan forms from Japan with comparable morphotypes in the Queen Charlottes include *Stichocapsa convexa* Yao, *Stichocapsa japonica* Yao, *Tricolocapsa fusiformis* Yao, and *Tricolocapsa rusti* Tan.

PART 2. SYSTEMATIC PALEONTOLOGY

(E.S. Carter)

INTRODUCTION

The earliest classification system for Radiolaria, proposed by Haeckel (1887a, b), was based on geometry of test shape. This was a comprehensive study and until recently has remained the major source of information on radiolarian taxonomy and diversity. With time, this classification nurtured a growing belief that radiolarians were not suitable for stratigraphy. Riedel (1971) was the first to suggest that Haeckel's classification was artificial (i.e. not based on clear phylogenetic lineages), and should be abandoned. Moreover, he demonstrated (in the late 1950's) the value of radiolarians in Cenozoic biostratigraphy. In recent years Radiolaria have been studied from both paleontological and ecological/physiological points of view, for only by incorporating both disciplines can a more natural system of classification be achieved (Petrushevskaya, 1971, 1983). Paleontologists have intensified their study of fossil forms and, subsequently, several excellent treatises on specialized topics have appeared that have adopted a more natural approach to classification (e.g., Riedel, 1967b, 1971; Petrushevskaya, 1971, 1979; Foreman and Riedel, 1972; Dumitrica, 1970, 1978a, b, 1979; Dumitrica, Kozur and Mostler, 1980; Goll, 1968, 1969; De Wever, 1984; and Nazarov and Ormiston, 1985). Studies on the living organism by Hollande and Enjumet (1960), Cachon and Cachon (1971, 1972, 1973, 1976a, b) and more recently by Anderson (1976a, b, 1977, 1980, 1983) and Anderson and Swanberg (1981), have contributed valuable information on the ontogeny of Radiolaria and functions of nutrition, locomotion and skeletal morphogenesis.

In summary, knowledge of Radiolaria has increased tremendously in specialized areas, but as yet no researcher has become sufficiently familiar with all the numerous species to recast them into a more natural and fundamentally different classification. At EURORAD III in Bergen, Norway, M.A. Petrushevskaya (1983) presented a preliminary draft of polycystine classification that was more comprehensive and detailed than any previous classification. It was expanded further at EURORAD IV in Leningrad, U.S.S.R. (Petrushevskaya, 1984).

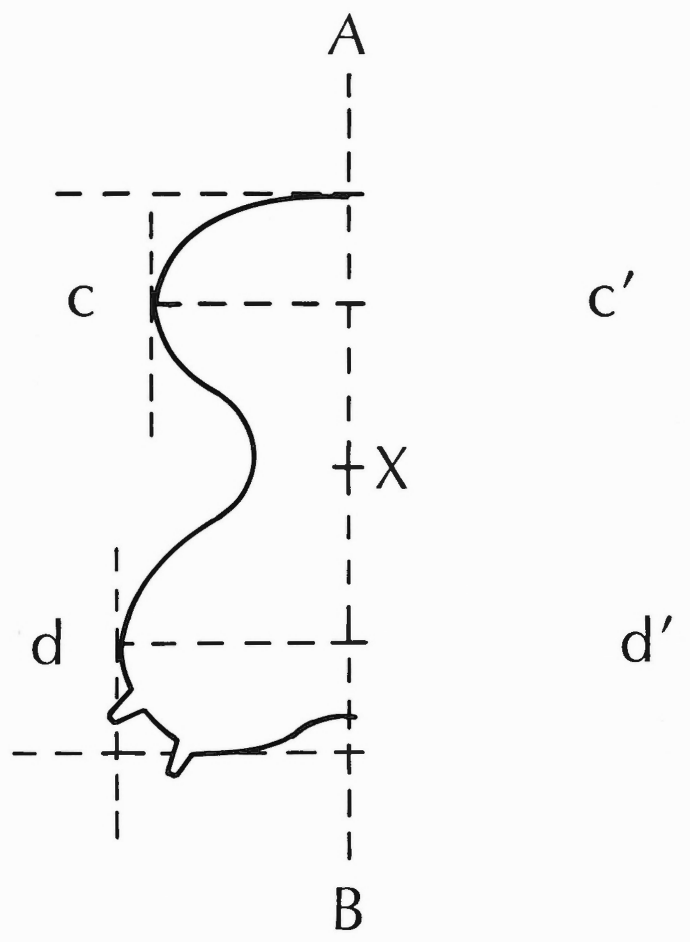


*Figure 9. Measurements for **Amphibrachium** (?) **phantomensis**. X = point at centre of area. A = point at end of shortest ray. B = point at end of longest ray. AX = length of shortest ray. BX = length of longest ray. cc′ = width of shortest ray. dd′ = width of longest ray (excluding spines).*

The present radiolarian taxonomy follows chiefly the polycystine systematic classification of Riedel (1967b, 1971) with some modifications by Baumgartner (1980), Deflandre (1963), De Wever (1981a, 1984), Dumitrica (1978b), Kozur and Mostler (1972b), Pessagno (1973, 1976, 1977a, b, 1979), Pessagno and Blome (1980), Pessagno and Whalen (1982), and Pessagno, Whalen, and Yeh (1986)[1].

Basis for description of new taxa

Definitions of new taxa are based on elements of internal structure as well as external diagnostic features of the cortical shell that are visible with the binocular or scanning electron microscope. Specimens were not viewed in transmitted light. Less certainly identifiable forms; for example, those poorly preserved, those with nondiagnostic or incompletely understood morphology, or those represented by insufficient numbers for variation to be documented, are recorded in open nomenclature. The distribution of each taxon is given both in Figures 4 and 5 (along with the relative abundance) and is discussed under "Occurrence".

[1]After this bulletin had been accepted for publication, a report was published by Yeh (1987) describing new taxa from east-central Oregon. Consequently some taxonomic changes have been made herein at the level of genus and species, but not family.

Measurements of the Hagiastridae and Patulibracchiidae follow a system of measurements proposed by Pessagno (1971, p. 18, Textfig. 4). The length of rays always includes the ray tip minus the spines. For other supraspecific taxa, measurements are normally self explanatory; where they are not, a diagram is included showing the system of measurements used (Fig. 9). Ranges are based on faunal correlations discussed under "Biostratigraphy".

Repository

Type specimens and some paratypes, illustrating specific morphological features, were mounted on standard aluminium SEM stubs, coated with gold/palladium and photographed with the scanning electron microscope. A technique described by De Wever (1980) for mounting radiolarians on SEM stubs gave the most satisfactory results. Holotypes and all illustrated material, as well as some unfigured specimens, are catalogued and deposited with the Geological Survey of Canada, Ottawa, under numbers GSC 80499 to GSC 80798. Most specimens remain attached to SEM stubs, others are mounted on cardboard micropaleontological slides.

Phylum PROTOZOA

Subclass RADIOLARIA Müller, 1858

Order POLYCISTINA Ehrenberg, 1838, emend. Riedel, 1967b

Suborder SPUMELLARIINA Ehrenberg, 1875

Family ACTINOMMIDAE Haeckel, 1862, emend. Riedel, 1967b

Genus *Staurosphaera* Haeckel, 1881

Staurosphaera Haeckel, 1881, p. 450.

Type species (by subsequent monotypy). *Staurosphaera crassa* Dunikowski, 1882, p. 187, Pl. 5, fig. 52.

? *Staurosphaera amplissima* Foreman

Plate 8, figures 10-12

? *Staurosphaera amplissima* Foreman, 1973, p. 259, Pl. 3, fig. 6.

Remarks. This form bears some resemblance to *Staurosphaera amplissima* Foreman. Foreman (1973) assigned numerous Mesozoic species, all bearing four main spines arranged as a cross, to *Staurosphaera* Haeckel, regardless of the nature or shape of shell and length of spines. This form possesses at least one medullary shell. Abundant in all upper Toarcian samples.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80537 and GSC 80538 from GSC localities C-080586 and C-080584, respectively. Other specimens (unfigured) found at GSC localities C-080581, C-080582, C-080583, C-080585, and C-080597.

Genus *Tripocyclia* Haeckel, 1882, emend. Pessagno, 1977a

Triactoma Rüst, 1885, p. 289 = *Triactus* Haeckel, 1881, p. 457 (type species *Triactoma tithonianum* Rüst, 1885).

Type species. Tripocyclia trigonium Rüst, 1885 (subsequent designation by Campbell, 1954, p. D 82).

Diagnosis. Cortical shell smooth, perforate, globular to subtriangular in outline and somewhat flattened, with three symmetrically placed, massive, tribladed spines.

Remarks. The interpretation used herein follows Pessagno's emended definition. He regards *Triactoma* Rüst, 1885 as a junior synonym of *Tripocyclia* Haeckel, 1882.

Tripocyclia rosespitense n. sp.

Plate 10, figure 1

Tripocyclia sp. A Yeh, 1987, p. 52, Pl. 3, fig. 9; Pl. 26, fig. 8.

Diagnosis. Test small, with uniform, mostly hexagonal, pore frames and three slender tribladed spines.

Description. Test small, spherical, and slightly flattened in plane of spines. Three triradiate spines are slender with alternating ridges and grooves. Ridges narrow and rounded; grooves about twice width of ridges. Terminal portion of spines normally pointed, but occasionally ridges widen at tip to produce a crown-like extension. Pore frames small, most are hexagonal, a few pentagonal.

Remarks. This species is similar in pore frame size and shape, and spine structure to *Tripocyclia trigonium* (Rüst), (Rüst, 1885, p. 23, Pl. 30(5), fig. 3; Parona, 1890, p. 155, Pl. 2, fig. 15; and Pessagno, 1977a, p. 80, Pl. 7, figs. 6, 7), but differs in having a distinctly spherical rather than subtriangular test shape.

Etymology. Named for Rose Spit, on the northeastern tip of Graham Island.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Diameter of test	141	143	150	140
Length of longest spine (on 4 complete specimens)	136	126	148	110

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zone 5: late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen (holotype) GSC 80502 from type locality. In east-central Oregon, Yeh (1987) records this species in upper Pliensbachian strata of the Nicely Formation and in lower Toarcian strata of the Warm Springs Member of the Snowshoe Formation.

Tripocyclia (?) sp. A

Plate 1, figure 4

Remarks. This species has larger pore frames and a more spiny appearance than any species of *Tripocyclia* previously described. Genus is queried because of the irregularly shaped pore frames.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80500 from GSC locality C-080577. Species recorded at this locality only.

Tripocyclia sp. B

Plate 10, figures 2, 3

Remarks. This species shows some affinity with *Tripocyclia blakei* Pessagno (1977a). It differs by having pentagonal as well as hexagonal pore frames, and spines that have enlarged blunt tips and a primary system of grooves only. *Tripocyclia blakei* has a primary and secondary system of grooves.

Range. Zones 4 to 6: late middle/early late Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80501 from GSC locality C-080597. Species found also at GSC localities C-080583, C-080584, and C-080586. Rare.

Family HAGIASTRIDAE Riedel, 1971, emend. Baumgartner, 1980

Remarks. Kozur and Mostler (1979) in their emended definition of the Superfamily Actinommacea excluded the Hagiastridae (originally introduced as Subfamily Hagiastrinae by Riedel, 1971, and later elevated to family level by Pessagno, 1971) because of the spongy wall structure of most forms. Both Riedel and Pessagno placed the Hagiastridae in a higher group, the Spongodiscidae Haeckel, emend. Riedel and the Spongodiscacea Haeckel, respectively, limited to forms having a spongy wall structure. The family as emended by Baumgartner confines the Hagiastridae to forms having 2 to 4 (or 5) rays with cortical and medullary shells and canals, and places it in homology with the Actinommidae Haeckel, emend. Riedel. A further group having a similar external shape but with irregular spongy wall structure is now confined to the Family Patulibracchiidae Pessagno, as emended by Baumgartner.

Subfamily HAGIASTRINAE Riedel, 1971, emend. Baumgartner, 1980

Genus *Homeoparonaella* Baumgartner, 1980

Type species. *Paronaella elegans* Pessagno, 1977a.

Homeoparonaella reciproca n. sp.

Plate 7, figures 2, 3

Diagnosis. Test has three rays of moderate (near equal) length with strongly expanded ray tips terminated by numerous short, fine spines. Pore frames and beams are aligned longitudinally, producing a pattern of single rows of square pore frames that alternate with double rows of triangular pore frames.

Description. Three-rayed test. Rays of moderate length, interradial angles subequal. Rays composed of 8-10 longitudinal beams with transverse bars oriented both perpendicular and oblique to the beams, forming single rows of square pore frames that alternate with double rows of triangular pore frames. Rays circular in axial section. Pore frames on ray tips are irregularly distributed, polygonal in shape.

Remarks. Rays are short and stout compared with those of *Homeoparonaella argolidensis* Baumgartner. *Homeoparonaella reciproca* differs from *H. hydensis* Yeh in having double rows of triangular pore frames alternating with single rows of square pore frames; *H. hydensis* has only linearly arranged square pore frames and is also much smaller. The alternating pore frame pattern between beams is diagnostic of *H. reciproca* but observable on well preserved specimens only.

Etymology. Latin, *reciprocus* (adj.), alternating. Refers to the alternating pattern of rows of square, and rows of triangular, pore frames between longitudinal beams.

Measurements (μm).

		Holotype	Average of 11 specimens	Max.	Min.
Lengths of rays	AX:	185	191	210	150
	BX:	202			
	CX:	202			
Width of rays		46-49	56	62	46
Width or ray tips		122-133	128	140	95
Length of longest spine		23	29	43	22

Type locality. GSC locality C-080584. See Appendix 1.

Range. Zones 2 to 4: middle to late middle/early late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen (holotype) GSC 80505, from type locality. Species recorded also at GSC localities C-080579, C-080582, C-080583, and C-080585.

Homeoparonaella sp. aff. *H. argolidensis* Baumgartner

Plate 7, figures 5, 6

aff. *Homeoparonaella argolidensis* Baumgartner, 1980, p. 288, Pl. 2, fig. 1, 8-12; Pl. 11, fig. 4.

Remarks. This species appears to be closely related to *Homeoparonaella argolidensis* and differs only by lacking a porous hump (with raised central tip) in the central area. If further study eventually proves this species to be *H. argolidensis*, then Baumgartner's quoted range of "late Bathonian - early Callovian to Tithonian" must be lowered considerably.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Figured specimen GSC 80503 from GSC locality 080584; species found also at GSC localities C-080581, C-080582, C-080583, C-080585, and C-080586. Eastern Oregon, Snowshoe Formation: Pessagno collection OR 501. Romania, Jasper Beds and Argolis Penninsula: see Baumgartner (1980).

Homeoparonaella sp. aff. *H. elegans* (Pessagno)

Plate 16, figure 7

? aff. *Rhopalastrum slavatum* Squinabol, 1903, p. 122, Pl. 9, fig. 3.

aff. *Paronaella elegans* Pessagno, 1977a, p. 70, Pl. 1, figs. 10, 11. De Wever et al., 1979, p. 88, Pl. 5, fig. 9.

aff. *Homeoparonaella elegans* (Pessagno) Baumgartner, 1980, p. 289, Pl. 1, fig. 15; Pl. 2, figs. 2-6; Pl. 11, fig. 6.

Remarks. This form differs from *Homeoparonaella elegans* by having less expanded ray tips, subaligned and tetragonal pore frames on almost all test surfaces, and by having less prominent nodes at pore frame vertices.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian. Range of *H. elegans* given by Baumgartner (1980) is "Middle Callovian - Oxfordian or older to Tithonian".

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80504 from GSC locality C-080587. Species collected also at GSC localities C-080585 and C-080588. *Homeoparonaella elegans* found in Central Japan: Yao collection In 7 (1972); Romania and Argolis Penninsula: see Baumgartner (1980); California: see Pessagno (1977a).

Genus *Hagiastrum* Haeckel, 1881, emend. Baumgartner, 1980

Type species. Hagiastrum plenum Rüst, 1885.

Hagiastrum sp. cf. *H. egregium* Rüst

Plate 7, figures 11, 12

cf. *Hagiastrum egregium* Rüst, 1885, p. 299, Pl. 34, fig. 5.

Tetratrabs sp. E Yeh, 1987, p. 32, Pl. 11, fig. 12; Pl. 22, fig. 2.

Remarks. This species compares closely with *Hagiastrum egregium*, except for the apparently twisted rays, the near equal length of all rays and the reduced size; overall length horizontally from ray tip to ray tip of this species is 600-800 µm, whereas in Rüst's type specimen this dimension is over 1100 µm. This species differs from *H.* sp. A by having fewer longitudinal beams and thus more slender arms.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80506 and GSC 80507 from GSC localities C-080583 and C-080597. Other specimens collected at GSC localities C-080581, C-080582, C-080584, C-080585, and C-080586. Nicely and Hyde formations and the Warm Springs Member of the Snowshoe Formation, east-central Oregon: see Yeh, 1987; western Switzerland: see Rust (1885).

Hagiastrum sp. A

Plate 2, figure 2

Remarks. Differs from *Hagiastrum* sp. cf. *H. egregium* (described above) by having slightly wider rays with more longitudinal beams per ray and by having a larger, more complex central area with smaller, more irregularly arranged pore frames. The lack of observed spines on ray tips may be because of poor preservation. This form bears no resemblance to other described species of *Hagiastrum*.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80508 from GSC locality C-080577.

Subfamily HIGUMASTRINAE Baumgartner, 1980

Genus *Higumastra* Baumgartner, 1980

Type species. Higumastra inflata Baumgartner, 1980.

Higumastra sp. A

Plate 10, figure 6

Remarks. This species has much coarser meshwork with correspondingly fewer and larger pores than any previously described species of *Higumastra*. In addition it has a larger, more inflated central area and more massive central spines. It has some affinity with *Astractura tetraxiphus* Rüst (1898, p. 22, Pl. 7, fig. 3), but has coarser meshwork with fewer pores and shorter spines.

Range. Zones 5 to 7: late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80510 from GSC locality C-080595. Species occurs only sparsely at GSC locality C-080597.

Genus *Pseudocrucella* Baumgartner, 1980

Type species. Crucella sanfilippoae Pessagno, 1977a.

Pseudocrucella sanfilippoae (Pessagno)

Plate 7, figures 1, 4

Crucilla sanfilippoae Pessagno, 1977a, p. 72, Pl. 2, figs. 15-16. Aita, 1982, Pl. 3, fig. 9.

Pseudocrucella sanfilippoae (Pessagno) Baumgartner, 1980, p. 291, Pl. 8, figs. 1, 23, 24. Kocher, 1981, p. 88, Pl. 16, fig. 1. non De Wever and Caby, 1981, Pl. 2, fig. 21.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian. Pessagno and Baumgartner, however, indicate its range as Kimmeridgian to Tithonian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80511 and GSC 80512 from GSC localities C-080597 and C-080583. Other specimens found at GSC localities C-080582, C-080584, C-080585, C-080586, C-080587, C-080594, and C-080595; California: see Pessagno (1977a); Greece: see Baumgartner (1980).

Pseudocrucella sp. A

Plate 7, figures 8, 9

Remarks. The rays on this form appear to expand slightly at tips (this is likely a preservational feature resulting from cortical shell being worn away to expose the more delicate inner structure). This species has affinity with

Pseudocrucella sp. C, illustrated by Baumgartner (1980, p. 292, Pl. 8, figs. 10, 11, 14). It differs in having larger, less numerous pore frames marked by stronger nodes, and in having shorter spines.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80513 from GSC locality C-080584. Species occurs also at GSC localities C-080583 and C-080585.

Pseudocrucella sp. B

Remarks. This form appears almost identical to *Pseudocrucella* sp. A of Baumgartner (1980, p. 292, Pl. 1, fig. 13; Pl. 8, figs. 3, 5, 7, 9, 13; Pl. 11, figs. 11, 12, 14), which he describes as being intermediate between *P. sanfilippoae* (Pessagno) 1977a and *P. adriani* Baumgartner, 1980. Its identity might be established if the actual specimens could be compared.

Range. Zone 7: early Bajocian. Baumgartner's sp. A occurs in strata of Oxfordian to Kimmeridgian age.

Occurrence. Graham Island Formation, Graham Island. Specimen GSC 80514 (not illustrated) occurs at GSC locality C-080588. Other specimens are found at GSC localities C-080587 and C-080593. Greece, Argolis Penninsula: see Baumgartner 1980, textfig. 5.

Pseudocrucella sp. C

Plate 7, figure 7

Pseudocrucella sp. C, Baumgartner, 1980, p. 292, Pl. 8, figs. 10, 11.

Range. Zones 2 to 5: middle to late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude Island and Graham Island, respectively. Illustrated specimen GSC 80516 from GSC locality C-080583. Species occurs also at GSC localities C-080579, C-080582, and C-080597. Greece, Argolis Peninsula and Romania (Margucera Formation): see Baumgartner (1980).

Pseudocrucella sp. D

Remarks. This form appears almost identical to *Pseudocrucella* sp. B illustrated by Baumgartner (1980, p. 292, Pl. 8, figs. 2, 6), which occurs in Greece in samples of Oxfordian and Kimmeridgian age. It differs from *P.* sp. C illustrated here by having a larger central area and shorter, wider rays.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Single specimens found at GSC localities C-080584 and C-080597.

Subfamily TRITRABINAE Baumgartner, 1980

Genus *Tetratrabs* Baumgartner, 1980

Type species. *Tetratrabs gratiosa* Baumgartner, 1980.

Tetratrabs sp. aff. *T. gratiosa* Baumgartner

Plate 7, figure 10

aff. *Tetratrabs gratiosa* Baumgartner, 1980, p. 294, Pl. 1, fig. 11; Pl. 5, figs. 2-7; Pl. 6, figs. 4-7, 9-14; Pl. 11, figs. 7-9.

Remarks. This form is remarkably similar to *Tetratrabs gratiosa* but differs by the presence of single rather than double pore rows between adjacent beams in some specimens. Moreover, measurements on a number of specimens indicate that the average size is about half that of *T. gratiosa.* This size difference may represent either an ecological variation or may indeed be a new species. It is also worth noting that Baumgartner considers the lower limit for *Tetratrabs* to be Callovian (based on information available to him in 1980). With further work on Toarcian and Aalenian forms it is possible that either the genus range will be lowered or that this form may be considered ancestral to *Tetratrabs* s.s.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80518 from GSC locality C-080584. Occurs also at GSC localities C-080582, C-080583, C-080585, and C-080597.

Subfamily TETRADITRIMINAE Baumgartner, 1980

Genus *Tetraditryma* Baumgartner, 1980

Type species. *Tetraditryma pseudoplena* Baumgartner, 1980.

Tetraditryma sp. aff. *T. pseudoplena* Baumgartner

non *Hagiastrum plenum* Rüst, in Pessagno, 1977a, p. 72, Pl. 2, fig. 14.

aff. *Tetraditryma pseudoplena* Baumgartner, 1980, p. 297, Pl. 1 fig. 9; Pl. 7, figs. 1-11. Baumgartner et al., 1980, p. 63, Pl. 2, fig. 1; Kocher, 1981, p. 98, Pl. 16, figs. 32-33. Sato et al., 1982, Pl. 3, fig. 7. Ishida, 1983, Pl. 11, fig. 7.

Remarks. This form is nearly identical to *Tetraditryma pseudoplena* but is smaller (rays 160-200 μm in length), and lacks stout lateral spines on ray tips. However, preservation of ray tips on the specimens in this study appears incomplete. Baumgartner notes that in Pessagno's material from Oregon, a form similar to *T. pseudoplena* exists but with "less strong lateral and equal central spines". He believes this variation is insufficient to warrant distinction of two different species. In addition, he mentions forms from the Middle Jurassic of Oregon and Central Japan that contain an ancestral species of *T. pseudoplena* that too is smaller and has a "reduced, porous cortical wall". Direct comparison of specimens from the Queen Charlotte Islands with those in Oregon and Japan might prove that this same ancestral species existed in the early Bajocian of the Queen Charlotte Islands.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Unfigured specimen GSC 80521 from GSC locality C-080595. Other specimens at GSC locality C-080588.

Tetraditryma sp. A

Plate 16, figures 9, 12

Remarks. This form bears no resemblance to any described species of *Tetraditryma* or to any known four-rayed form.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80519 from GSC locality C-080587.

Tetraditryma sp. B

Plate 16, figure 8

Remarks. Only two specimens of this small, delicate form are available for study at present.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80520 from GSC locality C-080595, to which this species appears to be confined.

Family PRAECONOCARYOMMIDAE Pessagno, 1976

Genus *Praeconocaryomma* Pessagno, 1976

Type species. Praeconocaryomma universa Pessagno, 1976.

Praeconocaryomma (?) *fasciata* n. sp.

Plate 1, figure 5

Diagnosis. Test large with many small, very closely spaced mammae. Mammae are directly connected to one another by heavy bars. Surfaces of mammae are flattened and finely perforate.

Description. Test large, subspherical with small, very closely spaced mammae. Mammae are small, knob-shaped, and possess minute rounded pores on their flattened distal surfaces. Mammae connected directly with massive bars. In some places these bars are so heavy and shortened that mammae almost merge. Five to six triangular to tetragonal intermammary pores surround each mamma. At least one medullary shell is present, but further details of inner structure cannot be determined at this time.

Remarks. Genus queried because the tubercles (termed mammae) are more knob-shaped than cone-shaped. Although they possess surface perforations, they normally lack radial spines, which are invariably present in *Praeconocaryomma.* In only one specimen have primary spines (two) been noted; they are circular in section.

Etymology. Latin, *fasciata* (adj.), growing together, banded.

Measurements (μm).

	Holotype	Average of 16 specimens	Max.	Min.
Diameter of cortical shell	225	207	252	150
Height of mammae	12	10	13	8

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zones 1 to 6: late Pliensbachian to Aalenian.

Occurrence. Fannin and Phantom Creek formations, Maude and Graham Islands, respectively. Illustrated specimen (holotype) GSC 80530 from the type locality, where species occurs in great abundance. Found also at GSC locality C-080586.

Praeconocaryomma immodica Pessagno and Poisson

Plate 1, figure 1

Acanthosphaera magnimamma Rüst, 1898, p. 12, Pl. 4, fig. 1.

non *Praeconocaryomma magnimamma* (Rüst) Pessagno, 1977a, p. 27, Pl. 5, figs. 14-16; Pl. 6, fig. 1.

Praeconocaryomma immodica Pessagno and Poison, 1981, p. 57, Pl. 7, figs. 2-9. Pessagno, Blome, and Longoria, 1984, p. 24, Pl. 1, figs. 22-24.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian. The range of *Praeconocaryomma immodica* was previously thought to be from the Toarcian to late Kimmeridgian/early Tithonian in California only (Pessagno and Poisson, 1981).

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80522 from GSC locality C-080577. Species occurs also at GSC localities C-080579 and C-080597. California: see Pessagno and Poisson (1981).

Praeconocaryomma whiteavesi n. sp.

Plate 1, figures 3, 6

Diagnosis. Spherical test with small, closely spaced porous mammae. Pores in intermammary areas normally much larger; elliptical and subtriangular in shape.

Description. Test spherical with small, closely spaced, porous mammae. Surfaces of mammae penetrated by a number of small circular pores centred around a small spine, which is circular in section. Pores in intermammary area irregularly sized; larger pores subtriangular in shape, smaller pores mostly elliptical. Occasional nodes arise near centres of intermammary areas where a number of pores converge. First medullary shell has pentagonal pore frames of varying size with weakly developed nodes at bar vertices. Sturdy triradiate beams connect medullary shell with mammae on cortical shell.

Remarks. This form is somewhat similar to *Praeconocaryomma* sp. aff. *P. magnimamma* (Rüst) illustrated by Pessagno and Poisson (1981, p. 59, Pl. 9, figs. 3-5). It differs by having smaller mammae and correspondingly larger intermammary areas with larger pores. These differences become even more apparent when this form is compared with *P. magnimamma* (Rüst) 1898 and *P.* sp. aff. *P. magnimamma* figured by Feary and Pessagno (1980, figs. 3, 4), and are considered significant enough to warrant designating this form a new species.

Etymology. Named in honour of J.F. Whiteaves, who studied the early paleontological collections from Maude Island.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Diameter of cortical shell	196	189	200	180
Height of mammae	15	14	20	11

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimens GSC 80528 (holotype) and GSC 80529 (paratype) from the type locality.

Praeconocaryomma sp. aff. *P. californiensis* Pessagno

Plate 17, figure 10

aff. *Praeconocaryomma californiensis* Pessagno, 1976, p. 41, Pl. 7, figs. 1-8.

Remarks. This form appears very similar in size and described characteristics to *Praeconocaryomma californiensis* s.s. It differs in having either five or six basal mammary pores and by lacking triradiate spines (over and above the normal fine circular spines). Furthermore, *P. californiensis* is much younger: it is Late Cretaceous in age.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80526 from GSC locality C-080587. Species occurs also at GSC localities C-080588, C-080593, C-080595, and C-080596.

Praeconocaryomma sp. aff. *P. mamillaria* (Rüst)

Plate 9, figure 2

aff. *Heliosphaera mamillaria* Rüst, 1898, p. 12, Pl. 4, fig. 2.

aff. *Praeconocaryomma mamillaria* (Rüst) Pessagno, 1977a, p. 77, Pl. 6, fig. 2.

Remarks. This form differs from *Praeconocaryomma mamillaria* s.s. by having subcircular to subtriangular, rather than distinctly triangular, pore frames surrounding mammae and in intermammary areas. It is also much smaller.

Range. Zones 2 to 5: middle to late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham Islands, respectively. Illustrated specimen GSC 80525 from GSC locality C-080597. Occurs commonly at GSC localities C-080579, C-080583, and C-080584.

Praeconocaryomma sp. aff. *P. media* Pessagno and Poisson

Plate 1, figure 2

aff. *Praeconocaryomma media* Pessagno and Poisson, 1981, p. 57, Pl. 8, figs. 1-4.

Remarks. This form differs from *Praeconocaryomma media* by having pentagonal rather than hexagonal shaped mammae and five rather than six basal mammary pores. It also has slightly more complex intermammary areas. It differs from *P. immodica* by having more widely spaced nodes with lower relief.

Range. Zones 1 and 2: late Pliensbachian to middle Toarcian.

Occurrence. Fannin and Whiteaves formations, Maude Island. Illustrated specimen GSC 80523 from GSC locality C-080577. Species also occurs at GSC locality C-080579.

Praeconocaryomma sp. aff. *P. parvimamma* Pessagno and Poisson

Plate 9, figure 1

aff. *Praeconocaryomma parvimamma* Pessagno and Poisson, 1981, p. 58, Pl. 7, figs. 5-8; Pl. 9, fig. 2.

Remarks. *Praeconocaryomma parvimamma* is thought to be the simplest (earliest) form in the *Praeconocaryomma* lineage (Pessagno and Poisson, 1981). It has six small mammary pores that slope gently outward from raised mammae. The legs of these pore frames interconnect with those of adjoining mammae, forming large subelliptical pores in intermammary areas. This form has an even more simple configuration and differs from *P. parvimamma* s.s. by completely lacking the small basal mammary pores and, in addition, is much smaller (90 and 97 μm in diameter in two specimens, as opposed to maximum and minimum diameters of 260 and 200 μm respectively, in *P. parvimamma*).

Range. Zone 5: late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80524 from GSC locality C-080597.

Praeconocaryomma sp. aff. *P. universa* Pessagno

Plate 17, figure 6

aff. *Praeconocaryomma universa* Pessagno, 1976, p. 42, Pl. 6, figs. 14-16.

Remarks. Form almost identical to *Praeconocaryomma universa*, but has circular rather than triradiate spines. It differs from *P.* sp. aff. *P. californiensis* (this report) by having more widely spaced (and larger) mammae with large sloping mammary pores.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80527, and other specimens, confined to GSC locality C-080588.

Genus *Acaeniotyle* Foreman, 1973

Type species. Xiphosphaera umbilicata Rüst, 1898

Definition. "Spherical or ellipsoidal shell with a surface of large porous nodes from which two or three spines extend" (Foreman, 1973, p. 258).

Remarks. Only four species of *Acaeniotyle* have been described hitherto. *A. diaphorogona* Foreman, 1973, *A. tribulosa* Foreman, 1973, *A. umbilicata* (Rüst) Foreman, 1973, and *A.* sp. A, Pessagno, 1977a. All are Late Jurassic and Early Cretaceous in age. The three forms described below are doubtfully assigned to this genus because nodes are smaller, knob-like rather than rounded, and have fewer perforations, and all are much older.

Acaeniotyle (?) *ghostensis* n. sp.

Plate 9, figure 6

Diagnosis. Test subspherical and slightly flattened with 3 long, sturdy, tribladed spines. Surface of cortical shell covered with strong, slightly perforate nodes.

Description. Test subspherical, flattened in plane of equatorial spines. Nodes on cortical shell strong, moderately spaced with somewhat flattened distal surfaces (tops); surfaces with fine perforations, some bearing remnants of fine central spines. Nodes connected by strong bars that form circular, elliptical and subtriangular pores. Spines tribladed and long (entire ones greater than 3/4 diameter of test) carrying narrow rounded ridges and wider grooves; complete spines are pointed. First medullary shell has small irregular pore frames connected to cortical shell by radial beams. Radial beams (3) are strong, triradiate and continuous with each primary spine; beams of lesser strength are attached to cortical shell at base of nodes.

Remarks. Genus queried; see "Remarks" under genus *Acaeniotyle.*

Etymology. Named for Ghost Creek, north of the type locality.

Measurements (μm).

	Holotype	Average of 13 specimens	Max.	Min.
Diameter of test	146	145	175	130
Length of longest spine	121	108	145	82

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zone 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen (holotype) GSC 80532 from type locality. Species also occurs at GSC localities C-080583, C-080584, and C-080585.

Acaeniotyle (?) sp. A

Plate 2, figure 3

Remarks. Genus queried; see "Remarks" under genus *Acaeniotyle.* This form, although smaller, is very similar to *Praeconocaryomma* (?) *fasciata* n. sp., except for the three strong equatorial spines; both are abundant in the same sample. This species differs from *Acaeniotyle* sp. B, by having a less spherical cortical shell with more closely spaced mammae.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80531 from GSC locality C-080577.

Acaeniotyle (?) sp. B

Plate 9, figure 3

Remarks. Genus queried; see "Remarks" under genus *Acaeniotyle.* A very small, delicate nodose form. Rare.

Range. Zone 5: late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80533 from GSC locality C-080597. All specimens confined to this locality.

Family STAUROLONCHIDAE Haeckel, 1881, emend. Pessagno, 1977a

Genus *Staurolonche* Haeckel, 1881, emend. Pessagno, 1977a

?*Staurosphaera* Haeckel, 1881, p. 450 (= nomen dubium) Pessagno, 1977a.

Type species. Staurolonche robusta Rüst, 1885. Subsequent designation by Campbell (1954, p. D 56).

Staurolonche ellsi n. sp.

Plate 8, figures 5, 6

Diagnosis. Surface of test covered with closely spaced heavy nodes arranged randomly. Spines long, tribladed near base, becoming circular in distal portions.

Description. Test square to rectangular, inner layer of cortical shell has irregularly sized subcircular to polygonal pore frames; outer layer composed of heavy, closely spaced nodes connected by regular bars to form triangular and tetragonal pore frames. Spines normally long and slender, tribladed at base, becoming circular distally.

Remarks. Species variable in form: sides of rectangle or square vary from straight to slightly concave; spines tend to be longer and retain their triradiate character throughout complete length in middle Toarcian specimens, whereas in late middle/early late Toarcian specimens, spines are normally shorter and predominantly circular in section. Extremely abundant at all reported localities.

Etmology. Named for R.W. Ells, whose early investigations of the Jurassic and Cretaceous rocks of Graham Island (1906) contributed to our current understanding of them.

Measurements (µm).

	Holotype	Average of 11 specimens	Max.	Min.
Length of test	124	130	150	110
Width of test	108	122	150	108
Length of longest spine	92	69	106	53

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zones 2 to 6: middle Toarcian to Aalenian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen (holotype) GSC 80549 from type locality. Unfigured specimens occur at GSC localities C-080579, C-080581, C-080583, C-080584, C-080585, and C-080586.

Staurolonche sp. aff. *S. extensa* Rüst

aff. ***Staurolonche extensa*** Rüst, 1885, p. 291, Pl. 29(9), fig. 3.

Staurolonche extensa Rüst ?, in De Wever, 1981c, p. 148, Pl. 5, fig. 26.

Remarks. This species compares with *Staurolonche extensa* Rüst ? illustrated by De Wever from upper Sinemurian ? - lower Pliensbachian limestones of Turkey. It differs in having narrower based, more slender spines. Lattice structure appears similar, but poor preservation of Queen Charlotte Islands specimens prohibits positive comparison. It differs from Rüst's original figure by having much shorter spines.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Single specimens found at GSC localities C-080583 and C-080587. Specimen GSC 80536 (not illustrated) from GSC locality C-080583.

Staurolonche sp. aff. *S. robusta* Rüst

aff. ***Staurolonche robusta*** Rüst, 1885, p. 291, Pl. 24(4), fig. 2; Pessagno, 1977a, p. 75, Pl. 4, fig. 8.

Remarks. This form is generally similar to Rüst's line drawing and to a form illustrated by Pessagno (1977a) from the Upper Jurassic of California. Preservation is such that size and shape of cortical shell and spines agree but meshwork is unclear in detail.

Range. Zones 1 and 2: late Pliensbachian to middle Toarcian.

Occurrence. Fannin and Whiteaves formations, Maude Island. Single specimens occur at GSC localities C-080577 and C-080579. Specimen GSC 80534 (not illustrated) from GSC locality C-080579.

Staurolonche (?) sp. A

Plate 8, figure 1, 4

Remarks. Inner layer of meshwork is very fine, appearing almost spongy; outer layer covered with weakly developed nodes. Test shape varies from rounded-square to rectangular in outline. Abundant in the lower part of Zone 4; much rarer in Zone 6.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80550 and GSC 80551 from GSC locality C-080583. Unfigured specimens occur at GSC localities C-080581, C-080582, C-080584, C-080585, C-080586, and C-080597.

Staurolonche (?) sp. B

Plate 8, figures 8, 9

Remarks. Test square and flattened with very fine meshwork and randomly arranged weak nodes on outer layer.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80552 from GSC locality C-080597. Other specimens occur at GSC localities C-080577 and C-080582.

Genus *Emiluvia* Foreman, 1973,
emend. Pessagno, 1977a

Type species. Emiluvia chica Foreman, 1973.

Diagnosis. Rectangular test with four spines, one at each corner arranged to form a cross. Surfaces of cortical shell planiform; sides concave to convex. Top and bottom surfaces of cortical shell with two layers: an inner layer of massive polygonal pore frames and a secondary outer layer consisting of nodes, connected by bars, forming triangular, tetragonal or irregularly polygonal pore frames. Sides of test are single layered. Primary spines have alternating longitudinal ridges and grooves.

Remarks. Emiluvia is interpreted in the emended sense of Pessagno as defined above. Pessagno's placement of *Emiluvia* in the Staurolonchidae Haeckel is based on the varying shape of pore frames in the secondary layer of the cortical shell. Foreman originally included *Emiluvia* with the Pseudoaulophacidae Riedel because of the pseudoaulophacid-like meshwork.

Range. Pessagno (1977a) states the range of *Emiluvia* as "Middle to Upper Jurassic". However, Baumgartner (1980), in discussing the origin of the Hagiastridae, notes that *Emiluvia*-like forms occur in a sample from the Rhaetian-Hettangian boundary in the Queen Charlotte Islands (Pessagno sample QC 545). Therefore, the range of *Emiluvia* must be extended to include the Lower Jurassic. It is certain that many species of *Emiluvia* are not only present but abundant in the Toarcian of the Queen Charlotte Islands.

Emiluvia acantha n. sp.

Plate 16, figures 3, 4

Diagnosis. Test square with concave sides. Surface of test covered with massive nodes particularly near base of spines. Spines tribladed, with small extensions on the ridge tips producing a modified crown-like structure.

Description. Test square in outline with four spines extending from corners. Top and bottom surfaces of cortical shell planiform, sides concave. Cortical shell composed of triangular and tetragonal pore frames with heavy to massive nodes at vertices of connecting bars. Nodes tend to be concentrated along ray axes and extend somewhat onto base of spines. Spines large, composed of three alternating longitudinal ridges and grooves; ridges have a thorn-like extension near their tip. Ridges wide and rounded, grooves narrow and deep.

Remarks. Differs from *Emiluvia salensis* Pessagno by having shorter spines with thorn-like extensions at the tips of spine ridges.

Etymology. Latin, *acanthus* (adj.), spiney, prickly.

Measurements (μm).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test	78	106	130	78
Length of longest spine	122	101	122	80

Type locality. GSC locality C-080596. See Appendix 1.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimens (holotype) GSC 80542 and (paratype) GSC 80543 from the type locality and GSC locality C-080588, respectively. Specimens occur also at GSC localities C-080593, C-080594, and C-080595.

? *Emiluvia antigua* (Rüst)

Staurosphaera antigua Rüst, 1885, p. 289, Pl. 28(3), fig. 2.

? *Emiluvia antigua* (Rüst) Pessagno, 1977a, p. 76, Pl. 4, figs. 9, 10.

Remarks. Genus and species doubtful because poor preservation obscures pore structure of cortical shell. In all other aspects this form is identical to that figured by Pessagno (1977a).

Range. Zone 7: early Bajocian. According to Rüst (1885, p. 289) this species ranges from the Middle Triassic to the Tithonian. In California it occurs at localities of late Kimmeridgian/early Tithonian age.

Occurrence. Graham Island Formation, Graham Island. Rare at GSC localities C-080587 (unfigured specimen GSC 80539), C-080589, and C-080594. California and Puerto Rico. see Pessagno (1977a). Rüst's illustrated type from the Aptychus Beds of Urschlau.

Emiluvia (?) *moresbyensis* n. sp.

Plate 4, figure 5

Diagnosis. Test outline a modified square with clearly concave sides. Surface nodes arranged along spine axes. Triradiate spines long and slender.

Description. Sides of test clearly concave in transverse section, which gives test an almost "four-armed" rather than square appearance. Surfaces planiform, sides vertical. Surface nodes arranged along spine axes: nodes uniform in size, pore frames irregularly sized, mostly triangular. Spines slender, length variable but normally long. Spine ridges and grooves continuous almost to tip.

Remarks. This form appears to be *Emiluvia*; however, its almost four-armed appearance suggests it may be a form transitional to the Hagiastridae Riedel, such as *Crucella* s.l. Detailed study of the internal structure would be necessary for correct generic assignment.

Etmology. Named for Moresby Island, south of type locality.

Measurements (μm).

	Holotype	Average of 8 specimens	Max.	Min.
Diameter of test	82	94	106	82
Length of longest spine	104	124	174	103

Type locality. GSC locality C-080579. See Appendix 1.

Range. Zones 2 to 5: middle to late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen (holotype) GSC 80548 from the type locality. Species also occurs abundantly at GSC localities C-080583, C-080584, C-080585, and C-080597.

Emiluvia oldmassetensis n. sp.

Plate 16, figure 6

Diagnosis. Test large, square with well defined, massive, triangular and tetragonal pore frames and massive nodes. Spines sturdy and tapering with strong, basal grooves.

Description. Test large, square and inflated with four spines, one at each corner of test. Test surfaces planiform. Large pore frames on outer layer of cortical shell composed of strong bars with large to massive nodes at their vertices; three to five nodes per row. Inner layer of pore frames triangular. Spines are subequal in length, taper strongly and have prominent ridges and grooves proximally. System of secondary grooves (moderate to weak) imposed on ridges. Spines become circular in distal section.

Remarks. Differs from *Emiluvia acantha* n. sp. in having a more square outline, randomly arranged nodes on upper and lower surfaces, and spines lacking thorn-like extensions.

Etymology. Named for the village of Old Masset on northern Graham Island.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Diameter of test	128	130	142	121
Length of longest spine	155	131	155	110

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen (holotype) GSC 80553 from the type locality. Other specimens of this species occur at GSC locality C-080594.

Emiluvia splendida n. sp.

Plate 16, figures 5, 11

Diagnosis. Test square and inflated. Surface covered with large rounded nodes. Four massive, tribladed spines of medium length. Terminal portion of each spine with crown-like structure, produced by small extensions or ridge tips.

Description. Test square and inflated with four massive corner spines. Upper and lower surfaces of test slightly convex and covered with well developed nodes connected by thin bars. Nodes much smaller on vertical sides of test. Pore frames square to triangular: inner pore frames small, subtriangular to irregularly polygonal. Spines sturdy with alternating longitudinal ridges and grooves. Ridges flattened, grooves wide, approximately 1.5 times width of ridges; ridges enlarge slightly at tips, extensions blunt-ended; central axis of spine extends to a fine point.

Remarks. This species has affinity with *Emiluvia hopsoni* Pessagno, but differs in having more convex surfaces, less massive nodes and much smaller crown-like structures on spine tips.

Etymology. Latin, *splendidus* (adj.), bright, shining.

Measurements (µm).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test	124	118	125	110
Length of longest spine	133	114	133	100

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimens GSC 80540 (holotype) and GSC 80541 (paratype) and all other specimens are confined to the type locality.

Emiluvia sp. aff. *E. pessagnoi* Foreman

Plate 4, figure 4

aff. *Emiluvia pessagnoi* Foreman, 1973, p. 262, Pl. 8, fig. 6.

Remarks. Differs from *Emiluvia pessagnoi* in having stronger concave sides in transverse section. It is also much smaller: width of shell from point midway between spines to opposite side, ranges from 94 to 133 µm, on 10 specimens.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80547 from GSC locality C-080595. Additional specimens found at GSC locality C-080588.

Emiluvia (?) sp. A

Plate 4, figure 1

Remarks. Genus queried because of the convex rather than planiform shape of test surfaces. Species occurs abundantly in pyritized fauna from GSC locality C-080579. It bears no resemblance to any previously described species of *Emiluvia.*

Range. Zones 2 to 4: middle to late middle/early late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80544 from GSC locality C-080579. Single specimen occurs at GSC locality C-080584.

Emiluvia (?) sp. B

Plate 4, figure 2

Remarks. Genus queried because upper and lower surfaces of test are slightly convex rather than planiform. Differs from *Emiluvia* (?) sp. A, in having smaller, more closely spaced nodes and less robust spines, not at 90°.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80545, and all other specimens, from GSC locality C-080579.

Emiluvia sp. C

Plate 4, figure 3

Remarks. Differs from *Emiluvia* (?) sp. B in having (1) a square, rather than rectangular shape, (2) less closely-spaced nodes and stronger bars and (3) more slender spines.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80546, and all other specimens from GSC locality C-080579.

Emiluvia sp. D

Plate 8, figures 2, 3

Remarks. Illustrated specimen has planiform surfaces bearing a few large pores. Other specimens have slightly convex surfaces with smaller and slightly smaller pores. For the present, and until further specimens are collected, all forms are included together in this one species. This form is generally similar to *Staurodoras mojsisovicsii* Dunikowski, 1882 (in Rüst, 1885, p. 292, Pl. 29(4), fig. 11); however, *Staurodoras* has a solid spongy sphere and lacks a differentiated medullary shell.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80535 from GSC locality C-080584. Species found also at GSC localities C-080583 and C-080597.

Emiluvia sp. E

Plate 15, figure 8

Remarks. Differs from *Emiluvia* (?) sp. B in having much larger nodes and shorter spines that are circular rather than triradiate.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80554 from GSC locality C-080589. Other specimens occur at GSC localities C-080587 and C-080588.

Genus *Tympaneides* n. gen.

Type species. Tympaneides charlottensis n. sp.

Description. Test is a flattened sphere (drum-shaped) with four spines extending from sides to form a cross in one plane. Top and bottom surfaces planiform, sides vertical to slightly concave. Latticed cortical shell composed of two layers of pore frames on planar surfaces and a single layer on the sides. Nodes on outer layer interconnected by fragile bars to form triangular or tetragonal pore frames.

Remarks. Tympaneides n. gen. is assigned to the Staurolonchidae Haeckel because of its shape, mode of shell construction and spine structure. It differs from *Emiluvia* Foreman in having a test that is circular and drum-shaped rather than rectangular, and from *Staurolonche* Haeckel in having a double-, rather than a single-layered cortical shell.

Etymology. Greek, *tympanon* (n.), drum.

Range. late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Queen Charlotte Islands.

Tympaneides charlottensis n. sp.

Plate 9, figures 4, 5

Diagnosis. Test circular, drum-shaped. Meshwork on planar surfaces very fine, pore frames triangular, nodes minute. Equatorial spines long, slender and triradiate.

Description. Test circular (drum-shaped) with four long spines extending from sides of test at 90° to one another. Outer layer of cortical shell covered with very small triangular pore frames composed of thin bars with fine nodes at their vertices. Spines long (one to three times test diameter), slender and of uniform width. Spines with alternating ridges and grooves. Ridges rounded and approximately twice as wide as grooves, which are narrow and deep.

Remarks. This species is very abundant in middle to upper Toarcian samples.

Etymology. This species is named for Queen Charlotte (wife of George III of England) after whom the Queen Charlotte Islands were named.

Measurements (μm).

	Holotype	Average of 14 specimens	Max.	Min.
Diameter of test	129	118	150	80
Length of longest spine	162	170	238	123

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens (holotype) GSC 80555 and (paratype) GSC 80556 from type locality. Other specimens (unfigured) found at GSC localities C-080584, C-080585, and C-080597.

Family PANTANELLIIDAE Pessagno, 1977b, emend. Pessagno, 1980

Subfamily PANTANELLIINAE Pessagno, 1977b, emend. Pessagno, 1980

Genus *Gorgansium* Pessagno and Blome, 1980

Type species. Gorgansium silviesense Pessagno and Blome, 1980.

Gorgansium silviesense Pessagno and Blome

Gorgansium silviesense Pessagno and Blome, 1980, p. 235, Pl. 11, figs. 2, 3, 11, 24.

Remarks. Test is slightly wider than normal for this species (CD measurement = 80 μm, described range = 65-75 μm; see Pessagno and Blome, 1980, Pl. 8, fig. 16 for system of measurements). Otherwise all measurements fall within the range given for the species.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. GSC 80558 (unfigured specimen) is one of three specimens occurring at GSC locality C-080590. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Genus *Pantanellium* Pessagno

? *Sphaerostylus* Haeckel, 1881 (= nomen dubium).

Type species. Pantanellium riedeli Pessagno, 1977a.

Pantanellium sp. cf. *P. haidaense* Pessagno and Blome

Plate 2, figure 1

cf. *Pantanellium haidaense* Pessagno and Blome, 1980, p. 242, Pl. 5, figs. 5, 18, 19, 21.

Remarks. Compared with *Pantanellium haidaense*, the cortical shell is wider (BB' ranges from 102-130 μm) and the spines are slightly longer. Nevertheless, other measurements fall within the given range for this species.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80559 from GSC locality C-080577. *Pantanellium haidaense* occurs in the upper Black Argillite Member of the Kunga Formation (= Sandilands Formation of Cameron and Tipper, 1985), Kunga Island, and in the middle and upper parts of the Maude Formation (= Rennell Junction and Fannin formations of Cameron and Tipper, 1985) at the type section on Maude Island (Pessagno and Blome, 1980).

Pantanellium sp. cf. *P. inornatum* Pessagno and Poisson

cf. *Pantanellium inornatum* Pessagno and Poisson, 1981, p. 56, Pl. 6, figs. 1-9. De Wever, 1981c, p. 144, Pl. 5, fig. 2. De Wever and Origlia, 1982, Pl. 7, fig. N.

Remarks. This species differs from *Pantanellium inornatum*, only in having a slightly larger cortical shell than the holotype and sharp and narrow, rather than rounded, spine ridges.

Range. Zone 1: late Pliensbachian. Pessagno and Poisson (1981, p. 49) limit the range of *P. inornatum* to the lower Pliensbachian. In addition they state (and illustrate, *Pantanellium* sp., Pl. 7, fig. 1 from QC 550, Kunga Formation, Q.C.I.) that unnamed forms from western North America in upper Sinemurian to lower Pliensbachian strata are closely related to *P. inornatum*. De Wever (1981c, p. 138) compared specimens from Pessagno and Poisson's type material with radiolarian faunas from North America and concluded that they are late Sinemurian to earliest Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Unfigured specimen GSC 80560 from GSC locality C-080577. Turkey, Gümüslü Allochthon: see Pessagno and Poisson (1981).

Pantanellium sp. cf. *P. cumshewaense* Pessagno and Blome

cf. *Pantanellium cumshewaense* Pessagno and Blome, 1980, p. 240, Pl. 6, figs. 12, 15, 17, 21, 22.

Remarks. This form differs from *Pantanellium cumshewaense* in having stronger nodes at vertices of pore frames, and spine ridges that are continuous for total length of spines rather than terminating in the distal third.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Unfigured specimen GSC 80561 from GSC locality C-080577. Found also at type section of the Maude Formation, Maude Island (Pessagno, QC 534), and from Snowshoe Formation, eastern Oregon (Pessagno and Blome, 1980).

Genus *Trillus* Pessagno and Blome, 1980

Type species. Trillus seidersi Pessagno and Blome, 1980.

Trillus elkhornensis Pessagno and Blome

Trillus elkhornensis Pessagno and Blome, 1980, p. 249, Pl. 6, figs. 11, 12, 16, 20, 25; Pl. 9, fig. 11.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian. This is consistent with the extended range for this species of late Pliensbachian to late early Bajocian (Pessagno and Blome, 1980).

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Unfigured specimens occur as GSC localities C-080585, C-080592, and C-080594. Eastern Oregon, Nicely and Snowshoe formations: see Pessagno and Blome (1980).

Trillus sp. cf. *T. seidersi* Pessagno and Blome

Plate 16, figure 1

cf. *Trillus seidersi* Pessagno and Blome, 1980, p. 249, Pl. 9, figs. 2-4, 9, 19.

Remarks. This form is almost identical to *Trillus seidersi*, but both cortical shell and spines are slightly more elongate.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80563 from GSC locality C-080592. Unfigured specimens occur also at C-080594. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Genus *Zartus* Pessagno and Blome, 1980

Type species. Zartus jonesi Pessagno and Blome, 1980.

Zartus jurassicus Pessagno and Blome

Zartus jurassicus Pessagno and Blome, 1980, p. 251, Pl. 7, figs. 5-7, 9, 11-13, 17, 19, 20, 24.

Remarks. Only a single specimen has been observed, but it appears identical in size and description to a paratype illustrated by Pessagno and Blome (Pl. 7, fig. 7; 1980).

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Unfigured specimen GSC 80564 from GSC locality C-080592. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Zartus thayeri Pessagno and Blome

Plate 16, figures 2, 10

Zartus thayeri Pessagno and Blome, 1980, p. 254, Pl. 8, figs. 3-6, Pl. 13, figs. 19-21.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80565 from GSC locality C-080592. Eastern Oregon, Snowshoe Formation: see Pessagno and Blome (1980).

Family HELIODISCIDAE Haeckel, 1881, emend. Kozur and Mostler, 1972

Subfamily HELIODISCINAE Haeckel, 1882, emend. Kozur and Mostler, 1972

Genus *Heliodiscus* Haeckel, 1882, emend. Kozur and Mostler, 1972

Type species. Heliodiscus inchoatus Rüst, 1885.

? *Heliodiscus inchoatus* Rüst

Plate 12, figures 2, 5

? *Heliodiscus inchoatus* Rüst, 1885, p. 293(23), Pl. 29(4), fig. 13. (Subsequent designation by Campbell, 1954, p. D84.)

Remarks. This form corresponds closely with Rüst's original drawing but differs in having fine spongy meshwork rather than medium-sized circular pores. Therefore, some doubt exists as to whether the specimens in this study should be retained in *Heliodiscus* or be reassigned elsewhere.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80566 from GSC locality C-080597. Other specimens collected at GSC locality C-080583. Rüst's illustrated type was from the Aptychus Beds of Urschlau.

Family PATULIBRACCHIIDAE Pessagno, 1971, emend. Baumgartner, 1980

Remarks. The Patulibracchiidae includes Spongodiscacea with two to five rays composed of uniform spongy meshwork (see Baumgartner, 1980, p. 297, for a detailed description). Riedel (1967b) and Pessagno (1971) originally included these forms within the Hagiastriidae. Furthermore, Kozur and Mostler (1978, p. 2) state that differences between spongy and latticed tests do not warrant suprageneric rank. Contrary to this opinion, the Hagiastriidae as emended by Baumgartner (1980) now includes only those forms with concentric shells and longitudinal canals and their skeletal structure is homologous with structures of the Actinommacea Haeckel, emend. Riedel. Baumgartner states (1980, p. 297) "the Patulibracchiidae differ from the Hagiastriidae by the lack of differentiated concentric shells and longitudinal canals".

Subfamily PATULIBRACCHIINAE Pessagno, 1971, emend. Baumgartner, 1980

Genus *Amphibrachium* Hertwig, 1879, emend. Baumgartner, 1980

Type species. Amphibrachium diminutum Rüst, 1885.

Amphibrachium (?) *phantomensis* n. sp

Plate 12, figure 1; Figure 9

Diagnosis. Two-rayed form with very fine, spongy meshwork. One or both rays variably bilobed.

Description. Two-rayed patulibracchiid with very fine, layered spongy meshwork. Tips of rays widely expanded and rounded; may form either one large lobe or bifurcate to form two smaller lobes. On some bilobed specimens lobes become elongate, giving the test an almost three-rayed appearance. Rays equal in length, very short and wide, no defined central area. Spines on ray tips vary from a single central spine to numerous fine ones.

Remarks. Genus is tentatively placed with *Amphibrachium* and queried because of the bilobed nature of ray tips. It is conceivable, however, that it is an extreme variant of *Paronaella spongiosa* n. sp. It is postulated that in the early late Toarcian a variant form of *Paronaella* had appeared (see Pl. 11, fig. 7); by the late Toarcian the figured two-rayed bilobed form (*A.* (?) *phantomensis* n. sp.) had evolved through enlargement of the primary ray and reduction of the secondary and tertiary rays to form a single bilobed ray.

Etymology. Named for Phantom Creek, south of type locality.

Measurements (μm).

		Holotype	Average of 10 specimens	Max.	Min.
Length of ray	AX	130	137	170	125
	BX	135	140	170	125
Width of ray	cc'	166	185	280	140
	dd'	209	232	280	180

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zones 3 to 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen (holotype) GSC 80567 from type locality. Unfigured specimens occur at GSC localities C-080581, C-080582, C-080583, C-080584, and C-080585.

Genus *Paronaella* Pessagno, 1971, emend. Baumgartner, 1980

Type species. Paronaella solanoensis Pessagno, 1971.

Remarks. The genus *Paronaella* is interpreted in the sense of Baumgartner (1980, p. 300), that is: "forms with bulbous or expanded ray tips are included". In this report, *Sontonaella* Yeh, 1987 is considered a subjective junior synonym of *Paronaella* Pessagno.

Paronaella bandyi ? Pessagno

Plate 11, figure 8

? *Paronaella bandyi* Pessagno, 1977a, p. 69, Pl. 1, figs. 1-3. Baumgartner, 1980, p. 300, Pl. 9, fig. 4.

Remarks. Identification is based on the morphology of the spines, which are identical to those of *Paronaella bandyi*. However, assignment is queried because the meshwork is totally obscured by adhering clay. Specimens very rare.

Range. Zone 4: late middle/early late Toarcian. *Paronaella bandyi* has previously been recognized as ranging from "(?) Callovian to Tithonian" (Baumgartner, 1980). If this form is the same species, then the range must be lowered to include the middle/late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80568 from GSC locality C-080585. Unfigured specimen from GSC locality C-080582. California: see Pessagno (1977a); Greece: see Baumgartner (1980); and central Japan: In 7, Yao collection (1972).

? *Paronaella denudata* (Rüst)

Plate 17, figure 1

Hymeniastrum denudatum Rüst, 1898, p. 27, Pl. 9, fig. 2.

Paronaella denudata (Rüst) Pessagno, 1977a, p. 70, Pl. 1, fig. 9.

Remarks. These specimens (14 in number) although poorly preserved, appear to be almost identical to those figured by Rüst and Pessagno. It is possible that the outer coarse meshwork is worn away in the central area, exposing an inner layer of smaller pore frames.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian. Further collecting and study will no doubt show whether this occurrence does indeed extend the lower range for the species. It was previously restricted to the late Kimmeridgian/early Tithonian to late Tithonian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80569, from GSC locality C-080588. Unfigured specimens occur at GSC localities C-080584, C-080587, C-080593, C-080594, and C-080595. California: see Pessagno (1977a).

Paronaella grahamensis n. sp.

Plate 11, figures 10-12

Diagnosis. Moderate in size with short rays, expanded tips and slender, almost cylindrical central spines. Rays subrectangular in cross-section.

Description. Three-rayed patulibracchiid of moderate size with slender central spines. Rays short, approximately equal in length. Tips enlarged and rounded; expansion may occur gradually throughout ray length or more abruptly in distal portion only. Pore frames irregular to sublinearly aligned, uniform in size, mostly tetragonal. Central spines on ray tips are slender, variable in length, circular in section. Rays subrectangular in cross-section.

Remarks. This abundant form is similar to, but much smaller than, *Paronaella bona* Yeh. Strong central spines are evident on almost all specimens.

Etymology. Named for Graham Island; type locality in central portion of island.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Length of longest ray	171	167	200	125
Width of ray	47	60	70	47
Width of ray tip	118	122	140	102
Length of longest spine	65	58	130	35

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80582 (holotype) and GSC 80581 (paratype) from type locality. Unfigured specimens collected at GSC locality C-080581, C-080582, C-080584, C-080585, C-080597, and C-080586.

Paronaella mulleri Pessagno

Paronaella mulleri Pessagno, 1977a, p. 71, Pl. 2, figs. 2, 3. Baumgartner, 1980, p. 304, Pl. 9, fig. 8.

Remarks. These specimens differ from *Paronaella mulleri* only by having slightly longer rays and a less elevated central area.

Range. Zone 7: early Bajocian. This occurrence extends the lower range for *P. mulleri*, which was previously known to range only from the Oxfordian/Kimmeridgian to the Tithonian.

Occurrence. Graham Island Formation, Graham Island. Unfigured specimens, including GSC 80570, are from GSC locality C-080595. Point Sal, California: see Pessagno (1977a); Argolis Peninsula, Greece: see Baumgartner (1980).

Paronaella skowkonaensis n. sp

Plate 11, figures 4, 5

Diagnosis. Three-rayed patulibracchiid having long, slender rays with clavate to wedge-shaped tips. Meshwork fine and irregular. Ray tips have numerous short fine spines.

Description. Test large with three long slender rays expanding at tips. Rays subequal in length at approximately 120°. Tips rounded to wedge-shaped. External pore frames small, sublinearly arranged; tetragonal to pentagonal with weak nodes at vertices. Numerous short, fine spines extend from ray tips of well preserved specimens. Internal meshwork layered and spongy.

Remarks. This form strongly resembles *Rhopalastrum trixiphus* Rüst, 1898, but differs in having several short spines rather than a single central one on each ray tip. It has been assigned to *Paronaella* because of its layered spongy meshwork.

Etymology. Named for Skowkona Mountain, southeast of the type locality.

Measurements (μm).

		Holotype	Average of 11 specimens	Max.	Min.
Lengths of ray	AX	217	202	269	170
	BX	269			
	CX	251			
Average width of rays		112	107	130	78

Type locality. GSC locality C-080584. See Appendix 1.

Range. Zones 1 to 6: late Pliensbachian to Aalenian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80575 (holotype), from type locality. Paratype, GSC 80576 from GSC locality C-080597. Unfigured specimens found at GSC localities C-080577, C-080579, C-080581, C-080582, C-080583, and C-080586.

Paronaella porosa n. sp.

Plate 4, figures 6, 9

Diagnosis. Test has short expanded rays, triradiate central spines and very fine spongy meshwork.

Description. Test composed of three (or, very rarely even four or five) rays. Rays short, of equal to subequal length, subrectangular in cross-section, gradually expanding and flattening slightly near the tips. Triradiate central spines moderate in length, sturdy. Pore frames on rays small, irregularly arranged; in the central area they are even smaller.

Remarks. This form has extremely fine meshwork and differs from all previously described species of *Paronaella.* An atypical four-rayed specimen, GSC 80585 from GSC locality C-080597 is figured (Pl. 4, fig. 9); it illustrates better the size difference of pore frames on the central area.

Etymology. Latin, *porosa* (adj.), full of holes.

Measurements (μm).

	Holotype	Average of 9 specimens	Max.	Min.
Length of ray	123	130	145	100
Width of ray tips	83	102	120	83
Length of longest spine	51	43	52	33

Type locality. GSC locality C-080584. See Appendix 1.

Range. Zones 2 to 4: middle to late middle/early late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen (holotype) GSC 80584 from the type locality. Unfigured specimens found at GSC localities C-080579, C-080582, C-080583, and C-080585.

Paronaella tlellensis n. sp.

Plate 17, figure 2

Diagnosis. Test small with an unusually distinct central area and three lobe-shaped rays; one ray may be larger than the other two. Spines triradiate; normally spines are centrally placed but sometimes two or three smaller spines terminate the larger ray. Surface covered with small circular pores.

Description. Test small, composed of three lobate rays surrounding a definite, slightly raised, central area; rays subequal in length becoming slightly flattened distally. Larger ray normally shorter and blunt-ended rather than round. Pore frames irregularly shaped, composed of thin bars with fine nodes at vertices. Pore frames in central area have additional silica deposited as burrs or thorns on their interior perimeter. Spines triradiate; normally there is one central spine per ray, however, occasionally two to three smaller spines terminate the larger ray.

Remarks. This form is similar in size and shape to *Paronaella* sp. cf. *P. mulleri* (Pl. 4, fig. 8), but differs in having more expanded ray tips, much finer meshwork and by sometimes having two or more spines on the enlarged ray. It differs from *P. mulleri* by having wider rays with more expanded tips and smaller, more irregular pore frames. *Paronaella mulleri* always has rays of nearly equal size with central spines only.

Etymology. Named for the town of Tlell, east of the type locality.

Measurements (μm).

	Holotype	Average of 8 specimens	Max.	Min.
Length of longest ray	140	121	140	100
Width of widest ray	92	83	110	68
Length of central spine	37	41	55	28

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen (holotype) GSC 80573 from type locality. Unfigured specimens occur at GSC localities C-080582, C-080583, C-080584, C-080585, C-080588, C-080590, and C-080594.

Paronaella variabilis n. sp.

Plate 11, figures 1-3

Diagnosis. Three-rayed patulibracchiid of variable morphology. Rays generally slender with greatly expanded elliptical, wedge or club-shaped tips. Mesh size irregular, coarse to medium, finer on ray tips. Rays terminate in numerous small spines.

Description. Three-rayed form variable in many respects. Rays moderately slender, expanding to large elliptical, club, or wedge-shaped tips. The largest interradial angle varies continuously from 120° to almost 150° (n = 81). Pore frames irregularly arranged on most specimens, sublinear on others; always smaller on ray tips. Pore frames triangular and tetragonal, nodes highly developed. Rays cylindrical to subrectangular in cross-section.

n = 81	Mean	Standard deviation
Maximum angle	128.41°	5.88
Minimum angle	111.99°	5.93

Remarks. A variable form extremely abundant in all upper Toarcian samples. Resembles *Paronaella* sp. cf. *P. kotura* figured by Baumgartner (1980, p. 304, Pl. 9, fig. 14), but lacks fine meshwork in central area and has numerous fine spines on ray tips. It differs from *P. kotura* by having highly variable interradial angles, shorter, wider rays with more expanded tips, and by lacking small pores in the central area.

Etymology. Latin, *variabilis* (adj.), changeable.

Measurements (μm).

		Holotype	Average of 10 specimens	Max.	Min.
Length of ray	AX	196	197	230	150
	BX	188			
	CX	182			
Width of ray		50	81	70	50
Width of tip		149	146	205	80

Type locality. GSC locality C-080584. See Appendix 1.

Range. Zones 1 to 6: late Pliensbachian to Aalenian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimens GSC 80578 (holotype) and GSC 80579 and GSC 80580 (paratypes) from the type locality and GSC locality C-080583, respectively. Unfigured specimens found at GSC localities C-080577, C-080581, C-080582, C-080585, C-080597, and C-080586.

Paronaella sp. aff. *P. grahamensis*

Plate 12, figure 3

Remarks. Ray width quite variable. Specimens with the shortest and widest rays have affinities with *Paronaella corpulenta* De Wever (1981b, p. 33, Pl. 2, figs. 7-9) and an even more inflated form illustrated by De Wever as *Paronaella* sp. cf. *P. corpulenta* (Pl. 3, fig. 7). The present species differs by having larger, less numerous pore frames, no observable secondary spines, and by lacking a well defined patagium. This species differs from *Paronaella* sp. D (this report) by having shorter, wider arms, coarser meshwork and triradiate spines.

Range. Zones 3 to 6: late middle/early late Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80583 from GSC locality C-080597. Unfigured specimens occur abundantly at GSC localities C-080581, C-080582, C-080583, C-080584, C-080585, and C-080586.

Paronaella sp. cf. *P. mulleri* Pessagno

Plate 4, figure 8

cf. *Paronaella mulleri* Pessagno, 1977a, p. 71, Pl. 2, figs. 2, 3, 9.

Paronaella sp. cf. *P. mulleri* Pessagno in Baumgartner, 1980, p. 304, Pl. 9, fig. 5; Pl. 12, figs. 4-7.

Remarks. This form appears almost identical to *Paronaella* sp. cf. *P. mulleri* Pessagno, described by Baumgartner (1980) from the Upper Jurassic of Greece.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80571, from GSC locality C-080579. All specimens confined to this locality.

Paronaella sp. cf. *P.* (?) *spinosa* (Parona)

Rhopalastrum (?) *spinosum* Parona, 1890, p. 159, Pl. 3.

Paronaella (?) *spinosa* (Parona) De Wever, 1981b, p. 34, Pl. 2, figs. 10-12; Pl. 3, figs. 1-4.

Remarks. This species is very closely related to *Paronaella* (?) *spinosa* (Parona) figured by De Wever (1981b), who queried the genus because "internal pores are aligned". The specimens in this study are not well enough preserved to permit this observation; secondary spines, diagnostic of *Paronaella* (?) *spinosa* are lacking, therefore only a "comparison" can be made. It is possible that the delicate secondary spines were lost during preservation.

Range. Zone 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Unfigured specimens including GSC 80572 from GSC localities C-080585 and C-080587.

Paronaella sp. A

Plate 4, figure 10

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80574 from GSC locality C-080577.

Paronaella sp. B

Plate 11, figure 6

Remarks. This form has some affinity with *Paronaella gemmata* De Wever (1981b, p. 33, Pl. 4, figs. 3-7), but ray tips are more enlarged and terminated by numerous fine spines rather than a single central spine. The presence of a bracchiopyle on one arm cannot be confirmed nor can the small secondary spines that characterize *P. gemmata.* It is possible that their absence is due only to imperfect preservation.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Maude and Graham Islands. Illustrated specimen GSC 80577 from GSC locality C-080584. Unfigured specimens occur at GSC localities C-080581, C-080582, C-080583, C-080585, C-080586, and C-080597.

Paronaella sp. C

Plate 11, figure 7

Remarks. This form is similar in size and shape to *Paronaella pygmaea* Baumgartner (1980, p. 306, Pl. 9, figs. 2, 9), but rays are wider in proportion to length and meshwork is finer and less regularly arranged.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80586 from GSC locality C-080583. Unfigured specimens from GSC localities C-080577 and C-080597.

Paronaella sp. D

Plate 11, figure 9

Remarks. Similar to *Paronaella denudata* (Rüst), but has shorter, more rounded arms, a slightly depressed rather than raised central area, less massive spines and less regularly arranged pore frames.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80587 from GSC locality C-080583. Unfigured specimens abundant at GSC localities C-080584, C-080585, and C-080597.

Paronaella sp. E

Plate 12, figure 6

Remarks. Appears similar to *Paronaella* sp. B illustrated in Pessagno, Finch, and Abbott, 1979, p. 165, Pl. 3, fig. 13, from the Upper Triassic (Carnian ?, Norian) of Baja, California.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80588 from GSC locality C-080585. Unfigured specimens occur at GSC localities C-080582, C-080583, and C-080584.

Paronaella sp. F

Plate 17, figure 3

Remarks. Massive spines on this species are diagnostic and differentiate it from all other described species of *Paronaella.*

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80589 from GSC locality C-080594.

Genus *Crucella* Pessagno, 1971, emend. Baumgartner, 1980

Type species. Crucella messinae Pessagno, 1971.

Crucella angulosa n. sp.

Plate 4, figures 11, 12

Diagnosis. Test cruciform. Rays medium to long and of uniform width, with long sturdy central spines.

Description. Test cruciform with medium to long rays terminated by long central spines. Rays uniform in width, of more or less equal length, diverging abruptly from the central area. Pore frames irregular in size, shape and arrangement; composed of thin bars with small rounded nodes at vertices. Rays rectangular in cross-section. Central spines have (three ?) wide, rounded, longitudinal ridges alternating with equally wide, strong grooves.

Remarks. This form, although extremely variable in ray length, bears no resemblance to any described species of *Crucella.* Indeed, the longer-rayed forms (e.g. Pl. 4, fig. 12), having finer bars and smaller nodes, may be found to represent another species when additional, better preserved specimens are found.

Etymology. Latin, *angulosus* (adj.), full of corners.

Measurements (μm).

	Holotype	Average of 10 specimens	Max.	Min.
Length of ray	111	124	191	111
Width of ray	39	51	66	39
Length of longest spine	95	71	119	45

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zones 1 to 4: late Pliensbachian to late middle/early late Toarcian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimens GSC 80591 (holotype) and GSC 80592 (paratype) from type locality. Unfigured specimens from GSC localities C-080579, C-080582, C-080583, C-080584, and C-080585.

Crucella sp. aff. *C. squama* (Kozlova)

Plate 12, figures 11, 12

Hagiastrum squama Kozlova, 1971, p. 1175, Pl. 1, fig. 10.

aff. *Crucella squama* (Kozlova) in De Wever, 1981b, p. 38, Pl. 5, fig. 7.

Remarks. This species differs from *Crucella squama* (Kozlova) figured by De Wever, by having much weaker spines.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian.

Occurrence. Fannin, Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80590 from GSC locality C-080583. Unfigured specimens from GSC localities C-080577, C-080582, C-080584, C-080585, and C-080597.

Crucella sp. A

Plate 15, figures 9, 12

Remarks. This form has minor affinity with *Crucella plana* Pessagno (1971), but differs in having an octagonally shaped central area, larger pore frames and heavier nodes.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80593 from GSC locality C-080593. Found also at GSC locality C-080594.

Family PSEUDOAULOPHACIDAE Riedel, 1967, emend. Pessagno, 1972

Remarks. In all reports up to the present, the Pseudoaulophacidae Riedel have been restricted in range to the Cretaceous. The only member of the family to be discussed herein is *Alievium*?. Reasons for inclusion are given in "Remarks" under genus *Alievium.*

Genus *Alievium* Pessagno 1972, emend. Foreman, 1973

Type species. Theodiscus superbus Squinabol, 1914.

Diagnosis. The genus *Alievium* as emended by Foreman includes triangular and circular forms, lacking tholi, with three primary spines occurring at corners of test, or radially arranged. Meshwork is coarse, massive, and uniform in size; pore frames triangular.

Remarks. In the following species descriptions, the generic assignment is questionable because the pore frames vary in some manner from the coarse triangular meshwork characteristic of *Alievium* s.s. and all other genera belonging to the Pseudoaulophacidae. In other respects they conform to the generic criteria for this family listed in Table 1, Pessagno (1972, p. 297). If further collecting and study eventually proves these forms to be *Alievium,* then the range for the genus, as well as the family, must be lowered considerably. It is far more likely that the specimens in this study are a form ancestral to the psuedoaulophacids, and if so should be assigned to a new genus, and possibly a new family.

Alievium ? *juskatlaensis* n. sp.

Plate 8, figure 7

Diagnosis. Test subcircular with fine surface meshwork and three slender tribladed spines.

Description. Cortical shell subcircular with three triradiate spines at 120° to each other. Surfaces of cortical shell convex. Meshwork delicate, composed of thin bars and small, but distinct, nodes. Pore frames uniform in size, triangular to tetragonal. Spines slender with ridges and grooves approximately equal in width. Some spines become circular distally.

Remarks. Genus queried because pore frames are variably shaped and fine, rather than coarse. See "Remarks" under genus *Alievium.*

Etymology. Named for the town of Juskatla, on Masset Inlet, north of the type locality.

Measurements (μm).

	Holotype	Average of 11 specimens	Max.	Min.
Diameter of test	180	155	190	135
Length of longest spine	134	128	160	110

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80595 (holotype) from the type locality. Unfigured specimens from GSC localities C-080582, C-080585, and C-080597.

Family ORBICULIFORMIDAE Pessagno, 1973

Genus *Orbiculiforma* Pessagno, 1973

Type species. ***Orbiculiforma quadrata*** Pessagno, 1973.

Orbiculiforma kwunaensis n. sp.

Plate 1, figures 8, 11

Diagnosis. Test disc-shaped, with rounded periphery and an undetermined number of short fine equatorial spines. Central cavity wide and deep, containing large, irregular pore frames.

Description. Test disc-shaped, thick, round in outline with numerous short equatorial spines. Central cavity wide and deep. Spongy meshwork fine and dense in the central cavity where pores are much larger and composed of fragile bars. Pore frames predominantly tetragonal and pentagonal, a few are triangular. Equatorial spines solid, slender, uniform in width.

Remarks. This species differs from *Orbiculiforma callosa* Yeh by having larger, rather than smaller, pore frames in the central area. A related, undescribed form from the same stratigraphic interval (Pl. 1, fig. 8, GSC 80598, GSC locality C-080577) has features similar to *O. kwunaensis,* but has a larger central cavity with smaller pore frames.

Etymology. Named for Kwuna Point on Moresby Island, southeast of type locality.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Maximum diameter of test	260	235	270	190
Maximum diameter of central area	132	108	132	80
Maximum length of spines	-	11	12	10

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80599 (holotype), and all other specimens, confined to type locality.

Orbiculiforma trispinula n. sp.

Plate 1, figures 7, 10

Diagnosis. Test discoidal with large central depression and three short radial spines. Meshwork spongy and coarse, pore frames larger in central area.

Description. Test a circular disc with large central cavity and three radial spines. Surface of test planiform, sides vertical. Central cavity large (approximately half test diameter) and deeply depressed. Pore frames polygonal and concentrically arranged; very small and delicate in the middle of the central area, but immediately surrounding ones are somewhat larger; composed of thin fragile bars. Pore frames on rim-like upper surfaces small, bars are coarser and small nodes occur at vertices of bars. Spines short and circular in section.

Remarks. This form differs from ***Orbiculiforma*** (?) ***trispina*** Yeh by having a larger overall diameter and thickness, a wider central cavity (and narrower rim) and much smaller radial spines.

Etymology. Latin, *trispinula* (adj.), three small spines.

Measurements (μm).

	Holotype	Average of 7 specimens	Max.	Min.
Maximum diameter of test	206	218	230	200
Maximum diameter of central cavity	134	130	155	110
Length of spines	46	43	46	40

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimens GSC 80596 (holotype) and GSC 80597 (paratype) from type locality.

Orbiculiforma sp. aff. *O. persenex* Pessagno

aff. *Orbiculiforma persenex* Pessagno, 1976, p. 35, Pl. 6, figs. 12, 13.

Remarks. Differs from *Orbiculiforma persenex* by having a smaller test (210 μm, compared with an average diameter of 251 μm [on 8 specimens], measured by Pessagno) and by having a much smaller central cavity.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. A single specimen GSC 80602, not figured, occurs at GSC locality C-080583.

Orbiculiforma sp. A

Plate 1, figure 9

Remarks. This form has minor affinity with *Orbiculiforma quadrata* Pessagno, (because of its rectangular outline and four triradiate spines), but differs significantly in having a much thicker test, massive pore frames and longer, stronger spines. A related undescribed form from the same stratigraphic interval is similar in shape, but more flattened, with rounded sides, a shallower central cavity, and weaker spines.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80600 from GSC locality C-080577. A few specimens collected at GSC locality C-080580.

Genus *Spongostaurus* Haeckel, 1882

Type species. Spongostaurus cruciatus Haeckel, 1887.

Remarks. This genus, formerly placed in the Spongodiscidae Haeckel, is assigned herein to the Orbiculiformidae Pessagno, because of its concentrically arranged spongy meshwork. All the following species of *Spongostaurus* are considered new, as they resemble no other described species. However, this genus has received little attention in modern literature.

Spongostaurus cruciformis n. sp.

Plate 10, figure 11

Diagnosis. Test rectangular, slightly indented along edges with short triradiate equatorial spines, shallow lacuna. Meshwork spongy, concentrically arranged.

Description. Test rectangular overall, edges slightly indented or concave, with four short, equatorial spines, one at each corner. Meshwork spongy, pore frames irregularly polygonal. Poorly defined shallow lacuna with central raised area appears on upper and lower surfaces of test. All four spines equal in length, strongly triradiate; ridges and grooves irregular in width.

Remarks. For comparison see "Remarks" under *Spongostaurus pugiunculus* n. sp.

Etymology. Latin, *cruciformis* (adj.), forming a cross.

Measurements (μm).

	Holotype	Average of 13 specimens	Max.	Min.
Maximum diameter of test	187	164	200	140
Length of longest spine	71	83	100	70

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80603 (holotype) from the type locality. Unfigured specimens from GSC localities C-080584, C-080585, and C-080597.

Spongostaurus pugiunculus n. sp.

Plate 17, figures 4, 5

Diagnosis. Test square and flattened with four massive, blade-like, obliquely tapering primary spines. Meshwork spongy; pores small and circular.

Description. Test square and flattened with four equatorial spines, one at each corner. Meshwork very fine and spongy. Pore frames irregularly polygonal, pores circular and concentrically arranged. Spines massive, subequal in length, triradiate and distinctive; composed of irregular ridges and grooves. Ridges wide and rounded; grooves very shallow. Blade-like spines taper obliquely to sharp points.

Remarks. Distinguished from *Spongostaurus cruciformis* n. sp. by having a more flattened test, finer meshwork and more massive spines that taper obliquely to sharp dagger-like points.

Etymology. Latin, *pugiunculus* (n.), a dagger.

Measurements (μm).

	Holotype	Average of 11 specimens	Max.	Min.
Maximum diameter of test	161	141	170	120
Length of longest spine	112	102	115	80

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zones 5 to 7: late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80604 (holotype) and GSC 80605 (paratype) from the type locality. Unfigured specimens from GSC localities C-080597, C-080588, C-080593, and C-080596.

Spongostaurus sp. A

Plate 10, figure 12

Remarks. Differs from *Spongostaurus cruciformis* n. sp and *S. pugiunculus* n. sp. in having a smaller test with convex surfaces; spines are more distinctly triradiate.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80606 from GSC locality C-080597. Additional unfigured specimens at GSC localities C-080585, C-080589, and C-080588.

Genus *Spongotrochus* Haeckel, 1860

Stylospongidium Haeckel, 1882

Type species. Spongotrochus brevispinus Haeckel, 1862.

Remarks. Genus is herein placed in the Orbiculiformidae Pessagno: see "Remarks" under genus *Spongostaurus.*

Spongotrochus tanaensis n. sp.

Plate 10, figures 8, 9

Diagnosis. Discoidal test with three radial primary spines and three or more interradial secondary spines. Meshwork fine and spongy. All spines solid, of uniform width, and circular in section.

Description. Test discoidal with three equally spaced radial primary spines and three or more secondary spines placed between primary spines. Upper and lower surfaces of test planar to slightly convex. Meshwork very fine, concentrically arranged; pore frames irregularly polygonal. Spines radiate from vertical sides of test. All spines very slender, solid, circular in section and blunt-ended. Primary spines are longer and larger in diameter than secondary spines.

Remarks. Differs from *Spongotrochus (Stylospongidium)* sp. aff. *S. (S.) echinodiscus* Clark and Campbell by lacking a depression in upper and lower surfaces and by having a primary and secondary system of spines.

Etymology. Named for Tana Point, on Graham Island, southwest of type locality.

Measurements (μm).

	Holotype	Average of 14 specimens	Max.	Min.
Diameter of test	167	184	220	133
Length of primary spines	81	127	150	81
Length of secondary spines	21	-	-	-

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80609 (holotype) and GSC 80610 (paratype) from the type locality and GSC locality C-080583, respectively. Unfigured specimens from GSC localities C-080582, C-080583, C-080584, and C-080585.

Spongotrochus (Stylospongidium) sp. aff.
S. (S.) echinodiscus Clark and Campbell

Plate 10, figures 7, 10

aff. *Spongotrochus (Stylospongidium) echinodiscus* Clark and Campbell, 1942, p. 48, Pl. 2, fig. 3.

Remarks. This form appears closely related to *Spongotrochus (S.) echinodiscus.* It differs by having a shallow depression in the upper and lower surfaces of the test and a fairly distinct, small, spongy, medullary shell in the centre of the test between the outer surfaces. *Spongotrochus (S.) echinodiscus* is restricted to the upper Eocene of California as far as is known. It is generally rare for radiolarian species to survive the Mesozoic/Cenozoic boundary, therefore it is unlikely that the specimens from this study are conspecific with *S. (S.) echinodiscus.*

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80607 and GSC 80608 from GSC locality C-080597. Unfigured specimens from GSC localities C-080583, C-080584, C-080585, C-080593, C-080594, and C-080595. Abundant, particularly at middle to late Toarcian localities.

Genus *Spongiostoma* n. gen.

Type species. Spongiostoma saccideon n. sp.

Diagnosis. Test disc-shaped, circular to subcircular with two large, closely spaced primary spines (both arising within a fifth to a seventh of the circumference); with or without secondary spines. Meshwork concentrically arranged. Spongy layers gape open from hinge area (beginning at base of primary spines).

Description. Test two layered, circular to subcircular in outline, surfaces planiform. Upper and lower layers of test hinged at one side and gape open at approximately 30°. Hinge marked by two strong primary spines (one at either end) that extend in equatorial plane and appear as "horns". Meshwork fine and spongy; meshwork arranged concentrically on inner surfaces of layers, irregularly on outer surfaces. Primary spines circular to triradiate. Test may or may not have fine radial secondary spines.

Remarks. The morphology of this form is most confusing. Test layers appear to gape open as if hinged at one side. Remaining edges of test are ragged, but there is no solid evidence that major parts are missing (e.g., additional primary spines). The gape could be a preservational feature (two layers of test have partially separated), but in over 50 specimens examined there is little variation in test morphology or angle of gape.

Etymology. Name formed from a combination of *spongi* (Greek, n., sponge) and *stoma* (Greek, *stoma, stomatos,* mouth), *spongi-o-stoma* = spongy mouth.

Range. Early Jurassic: late middle to late Toarcian, so far as is known.

Occurrence. Phantom Creek Formation, Queen Charlotte Islands.

Spongiostoma saccideon n. sp.

Plate 12, figures 4, 7, 10

Diagnosis. Test subcircular in outline, composed of two spongy concentric layers which gape open. Short hinge on one edge marked by two strong triradiate spines; periphery with a few very fine secondary spines.

Description. Test as for genus; subcircular in outline. Hinge normally short and straight with a well defined, triradiate primary spine on either end. A few short and very fine, secondary spines radiating from the circular periphery have been noted on some tests.

Remarks. Compared to *Spongiostoma* sp. A under that species. Common to very abundant in middle/upper Toarcian samples.

Etymology. Latin, *saccus* (n.), bag, sack or pouch; *saccideon* = of sack-like appearance.

Measurements (μm). Measurements are treated in a very preliminary manner as many of these specimens appear incomplete.

	Holotype	Average of 11 specimens	Max.	Min.
Maximum diameter of test	212	207	250	160
Length of hinge (between centres at margin	109	100	120	76
Length of longest spine	109	124	165	80

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 4 and 5: late middle/early late to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80611 (holotype) and GSC 80612 (paratype) from the type locality. Additional specimens from GSC localities C-080584, C-080585, and C-080597.

Spongiostoma sp. A

Plate 12, figures 8, 9

Remarks. Compares superficially with *Spongodiscus* sp. figured by Iwata, Uozumi, Nakamura and Tajika, 1983, Pl. 1, fig. 8. *Spongodiscus* sp., however, has a subcircular test and four spines arranged as an "X"; nothing can be seen of its inner meshwork. *Spongiostoma* sp. A differs from *S. saccideon* n. sp. by having a more circular test and massive spines that are circular, rather than triradiate, in axial section.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80613 from GSC locality C-080583.

Family SPONGODISCIDAE Haeckel, 1862, emend. Riedel, 1967b

Genus *Spongotripus* Haeckel, 1882

Type species. Spongotripus regularis Haeckel, 1887.

Remarks. It is likely that this form possesses a concentrically arranged meshwork. However, until this can be clearly ascertained, *Spongotripus* should remain within the Spongodiscacea Haeckel.

Spongotripus incomptus n. sp

Plate 10, figure 5

Diagnosis. Test triangular to rounded-triangular; upper and lower surfaces normally convex. The three spines, at corners, are slender and triradiate; becoming circular distally. Meshwork fine and spongy.

Description. Test triangular to rounded triangular in outline with three slender spines, one at each corner. Surfaces of test strongly convex to flattened. Meshwork very fine and spongy. Spines vary: normally they are triradiate and become circular in distal half, but some are mostly circular throughout.

Remarks. This form resembles *Spongotripus trigonus* Rüst (1898, p. 34, Pl. 11, fig. 13). However, Rüst's drawing lacks details of pore structure, and without this a true comparison cannot be made.

Etymology. Latin, *incomptus* (v.), unadorned.

Measurements (μm).

	Holotype	Average of 11 specimens	Max.	Min.
Maximum diameter of test	141	153	195	122
Length of longest spine (broken on holotype)	58	95	130	70

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80614 (holotype) from type locality. Unfigured species from GSC localities C-080582, C-080584, C-080585, C-080594, C-080595, and C-080597. Abundant in middle to upper Toarcian, less frequent in lower Bajocian.

Unnamed spongodiscid

Plate 10, figure 4

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80499 from GSC locality C-080583. This species collected also at GSC localities C-080584 and C-080585.

Family SATURNALIDAE Deflandre, 1953, emend. De Wever, 1984

Subfamily SATURNALINAE Deflandre, 1953, emend. De Wever, 1984

Genus *Mesosaturnalis* Kozur and Mostler, 1981, emend. De Wever, 1984

Type species. Palaeosaturnalis levis Donfrio and Mostler, 1978.

Mesosaturnalis hexagonus (Yao)

Plate 9, figures 11, 12

Spongosaturnalis (?) *hexagonus* Yao, 1972, p. 31, Pl. 6, figs. 1-3, Pl. 11, fig. 3a-c).

Remarks. Appears identical to the species described by Yao. This taxon conforms to the emended definition of

Mesosaturnalis (De Wever, 1984), therefore the genus name has been changed herein from *Spongosaturnalis* (originally queried by Yao) to *Mesosaturnalis.*

Range. Zones 4 to 7: late middle/early late Toarcian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80615 and GSC 80616 from GSC localities C-080583 and C-080586, respectively. Also from GSC localities C-080584, C-080585, C-080597, and C-080588. Central Japan: see Yao (1972).

Mesosaturnalis sp. cf. *M. septispinus* (Yao)

Plate 9, figure 10

cf. *Spongosaturnalis* (?) *septispinus* Yao, 1972, p. 32, Pl. 6, figs. 4-6.

Remarks. Compares closely with *Spongosaturnalis septispinus*, but has much shorter peripheral spines. Genus changed to *Mesosaturnalis*; see "Remarks" under *M. hexagonus.*

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80617 from GSC locality C-080584. Rare. Central Japan: see Yao (1972).

SPUMELLARIINA **incertae sedis**

Genus *Stephanastrum* Ehrenberg, 1847

Type species. Stephanastrum rhombus Ehrenberg, 1854 (subsequent designation by Campbell, 1954, p. D 88).

Diagnosis. Four undivided arms; patagium with four large interbrachial openings.

Stephanastrum ? *magnum* n. sp.

Plate 1, figure 12

Diagnosis. Test large, subrounded in outline with four equally spaced primary spines and coarse lattice meshwork.

Description. Test large, discoidal, subrounded in outline, with four slender, equally-spaced primary spines extending from periphery in equatorial plane. Test surfaces convex, sides rounded. Spines on all specimens broken off near base but may (?) extend inward. Outer portion of test consists of three concentric layers of small polygonal pore frames; inner pore frames much larger. On outer surfaces, pore frames are large in central area, becoming smaller toward the periphery of the test. Pore frames triangular and tetragonal. One or two small indentations (about five times the size of an average pore), slightly off-centre, can be distinguished on upper and lower surfaces.

Remarks. Genus queried because it differs from *Stephanastrum* as defined by Campbell, by possessing a more discoidal test with poorly differentiated arms. This form is somewhat similar to *S. orbiculare* (Rüst, 1898, p. 32, Pl. 10, fig. 10). However, Rüst's illustration shows a form with very little detail of pore frame structure, particularly in the central portion of the test, and appears to have four internal rays but no exterior spines. Moreover, according to Campbell (1954, p. D 88) *Stephanastrum* ranges from Eocene to Recent. It is likely that further study of the internal structure will prove this form to be significantly different and worthy of assignment to a new genus.

Etymology. Latin, *magnus* (adj.), large, great.

Measurements (μm). Test diameter measured diagonally between spines.

	Holotype	Average of 6 specimens	Max.	Min.
Test diameter AA'	352	318	352	284
Test diameter BB'	310	327	360	310

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80618 (holotype) from type locality.

Genus *Caltrop* n. gen.

Type species. Caltrop nodosum n. sp.

Diagnosis. Test tetrahedron-shaped with four tribladed spines, one at each corner. Meshwork latticed and massive.

Description. Test shaped as a tetrahedron with four triradiate primary spines, one extending from each corner or triple junction. Each of four test surfaces is planar and shaped as an equilateral triangle. Cortical shell latticed with massive pore frames composed of heavy bars with nodes of variable size at vertices. Internal structure not determined.

Remarks. Caltrop differs from *Emiluvia* Foreman by being tetrahedral, rather than a flattened rectangle, in shape, and by having spines extending in four planes rather than in a single, equatorial one. From current studies the cortical shell appears to be single-layered; *Emiluvia* has a double-layered cortical shell.

Etymology. Name derived from Medieval Latin *calcitrappa*, a four-pointed weapon placed on the ground to impede the movement of the enemy.

Range. Early Jurassic (late middle/early late Toarcian), so far as is known.

Occurrence. Fannin Formation, Queen Charlotte Islands.

Caltrop nodosum n. sp.

Plate 9, figures 7-9

Diagnosis. Test tetrahedron-shaped with four primary tribladed spines. Meshwork coarse and latticed with massive nodes at vertices of pore frames.

Description. Test as for genus. Pore frames on test surfaces triangular and tetragonal with massive nodes at vertices. Each side bordered by four nodes; sides joined together by heavy bars forming large tetragonal pore frames. Spines tribladed, moderate in length with longitudinal ridges and grooves; ridges narrrow and rounded, grooves wide and deep. Spine tips, when entire, are sharp.

Remarks. Rare in all middle to upper Toarcian samples. Absent so far in both older and younger well preserved material.

Etymology. Latin, *nodosus* (adj.), nodose.

Measurements (μm).

	Holotype	Average of 6 specimens	Max.	Min.
Length of triangular side	120	119	140	90
Length of longest spine	90	86	110	70

Type locality. GSC locality C-080584. See Appendix 1.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80619 (holotype) from type locality. Unfigured specimens from GSC localities C-080582, C-080583, and C-080585.

Genus *Dicroa* Foreman, 1975

Type species. Dicroa periosa Foreman, 1975.

Dicroa (?) sp(p).

Diagnosis. Complete spines are triradiate with area of attachment at one end and strongly bifurcating tips at the other. There are two distinct forms, one has spine bases and straight spine tips arranged as a "Y" in one plane, whereas the other form has tips that curve inward and point in opposite directions, not in the same plane.

Remarks. Included are two forms of slightly varying morphology, questionably assigned to *Dicroa*. Foreman (1975) defines *Dicroa* as "a spherical or elliptical shell bearing two or three bifurcating spines". As whole spines only are preserved, identification is indeterminate. Specimens do compare closely with those figured by Foreman (1975, Pl. 2E, figs. 8-11; Pl. 3, fig. 8) and Pessagno (1977b, Pl. 4, figs. 2, 3, 5). All previously described forms of *Dicroa* are Cretaceous.

Range. Both forms confined to Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Unfigured specimens GSC 80620 and 80621 found at GSC localities C-080589, C-080592 and C-080593.

Suborder NASSELLARIINA Ehrenberg, 1875

Family ARCHEODICTYOMITRIDAE Pessagno, 1976

Genus *Archeodictyomitra* Pessagno, 1976

Type species. Archeodictyomitra squinaboli Pessagno, 1976.

Archeodictyomitra sp. aff. *A. primigena* Pessagno and Whalen

aff. *Archeodictyomitra primigena* Pessagno and Whalen, 1982, p. 116; Pl. 10, figs. 9, 17; Pl. 13, fig. 4.

Archeodictyomitra sp. Hattori and Yoshimura, 1983, Pl. 9, fig. 3.

Remarks. In all samples studied, only two specimens of *Archeodictyomitra* have been recovered. Both are pyritized and detail of pores in intercostal areas is obscured by overgrowths of pyrite. Although they appear to be closely related to *A. primigena* (and also to *A.* sp., figured by Hattori and Yoshimura), the specimens in this study are larger (length 155 μm, maximum width 90 μm), and less rounded apically.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Unfigured specimen GSC 80622 from GSC locality C-080579.

Genus *Mita* Pessagno, 1977b

Type species. Mita magnifica Pessagno, 1977b.

Mita sp. A

Plate 17, figure 9

Remarks. This form is much shorter and broader than any known described species of *Mita*. It is rare but distinct in youngest early Bajocian samples.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80623 from GSC locality C-080595. Other specimens from GSC localities C-080593 and C-080594.

Family BAGOTIDAE Pessagno and Whalen, 1982

Genus *Droltus* Pessagno and Whalen, 1982

Type species. Droltus lyellensis Pessagno and Whalen, 1982.

Droltus sp. cf. *D. lyellensis* Pessagno and Whalen

Plate 3, figure 7

cf. *Droltus lyellensis* Pessagno and Whalen, 1982, p. 122; Pl. 2, fig. 3, 10; Pl. 12, fig. 7.

Remarks. Form compares closely with *Droltus lyellensis*, but tetragonal pore frames are less aligned and the single specimen found (and figured) is larger. length (excluding horn) 331 μm, maximum width 208 μm. *Droltus lyellensis* has previously been recorded from the upper Sinemurian portion of the Kunga Formation, Queen Charlotte Islands.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80624 from GSC locality C-080577.

Droltus sp. A

Plate 17, figure 12

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Two specimens, of which one is illustrated (GSC 80625), are from GSC locality C-080593.

Family CANOPTIDAE Pessagno, 1979

Genus *Canoptum* Pessagno, 1979

Type species. Canoptum poissoni Pessagno, 1979.

Canoptum sp. cf. *C. dixoni* Pessagno and Whalen

Plate 14, figure 10

cf. *Canoptum dixoni* Pessagno and Whalen, 1982, p. 124; Pl. 2, figs. 1, 2, 8, 9, 14; Pl. 12, fig. 2.

Remarks. This form is almost identical to *Canoptom dixoni*; it differs only in having somewhat larger pore frames.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian.

Occurrence. Fannin and Whiteaves formations, Maude Island; Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80626 from GSC locality C-080597, other specimens from GSC localities C-080577, C-080579, and C-080583.

Canoptum anulatum Pessagno and Poisson

Plate 5, figures 9, 10, 14

Canoptum anulatum Pessagno and Poisson, 1979, p. 60; Pl. 9, figs. 6-9; Pl. 10, figs. 1-9; Pl. 15, figs. 2, 4. Pessagno and Whalen, 1982, p. 123; Pl. 6, figs. 1, 2.

Remarks. The pyritized fauna from GSC locality C-080579 contains abundant forms broader based but otherwise very similar to *Canoptum anulatum*. Present also are a number of extremely large forms (see Pl. 5, fig. 9, GSC 80627) with weaker ridge ornamentation, that appear closely related to *C. anulatum*.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimens GSC 80628 and GSC 80627 from GSC locality C-080579. Lower Jurassic of Turkey, California, Oregon, Baja California Sur: see Pessagno and Whalen (1982).

Canoptum (?) sp. A

Plate 14, figure 6

Canoptum (?) sp. A, Pessagno and Whalen, 1982, p. 125, Pl. 7, figs. 14, 16.

Remarks. Genus queried because form possesses two rows of primary pores in H-linked configuration flanking both sides of each circumferential ridge, and two rows of offset relict pores between the ridges.

Range. Zones 3 to 5: middle to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80629 from GSC locality C-080597. An additional specimen was collected at GSC locality C-080579.

Genus *Wrangellium* Pessagno and Whalen, 1982

Type species. Wrangellium thurstonense Pessagno and Whalen, 1982.

Wrangellium oregonense Yeh, in press

Plate 6, figures 8, 11

Wrangellium oregonense Yeh, in press, Yeh, 1987, p. 58, Pl. 15, figs. 5-7, 14, 18, 19, 24; Pl. 27, figs. 3, 22.

Remarks. This form closely resembles *Wrangellium* sp. A figured by Pessagno and Whalen (1982, p. 126; Pl. 3, figs. 2, 8, 9), but is broader based and possesses fewer post-abdominal chambers. Rare.

Range. Zones 1 and 2: late Pliensbachian to middle Toarcian.

Occurrence. Fannin and Whiteaves formations, Maude Island. Illustrated specimen GSC 80630 from GSC locality C-080577.

Family CANUTIDAE Pessagno and Whalen, 1982

Genus *Canutus* Pessagno and Whalen, 1982

Type species. Canutus tipperi Pessagno and Whalen, 1982.

Canutus nitidus Yeh

Plate 3, figures 5, 8, 12

Canutus nitidus Yeh, 1987, p. 59-60, Pl. 6, figs. 1, 17; Pl. 19, figs. 1, 2, 6, 11, 18, 19.

Remarks. No narrow tubular extension terminating the distalmost post-abdominal chamber, as described by Yeh (1987, p. 59), has been observed in any specimens.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimens GSC 80635 and GSC 80642 recovered from GSC locality C-080577.

Canutus giganteus Pessagno and Whalen

Plate 3, figure 1

Canutus giganteus Pessagno and Whalen, 1982, p. 127; Pl. 4, figs. 5, 13.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80636 from GSC locality C-080577.

Canutus hainaensis Pessagno and Whalen

Plate 3, figures 10, 11

Canutus hainaensis Pessagno and Whalen, 1982, p. 128, Pl. 4, figs. 3, 4; Pl. 5, figs. 1, 13, 14, 16-18, 20; Pl. 12, fig. 9.

Remarks. Specimens generally larger (length 350-476 µm) than those from Pessagno and Whalen's type material, but otherwise they appear identical.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80637 and all others from GSC locality C-080577.

Canutus izeensis Pessagno and Whalen

Plate 3, figure 2

Canutus izeensis Pessagno and Whalen, 1982, p. 129, Pl. 6, figs. 8, 10, 15.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimens GSC 80638 from GSC locality C-080577.

Canutus tipperi Pessagno and Whalen

Plate 3, figure 3

Canutus tipperi Pessagno and Whalen, 1982, p. 129, Pl. 4, figs. 7-9, 11, 12, 14-17; Pl. 12, fig. 21.

Range. Zone 1: late Pliensbachian (extending the range known hitherto).

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80639 and all others from GSC locality C-080577.

Canutus sp. aff *C. nitidus* Yeh

Plate 3, figure 6

aff. *Canutus nitidus* Yeh, 1987, p. 59-60, Pl. 6, figs. 1, 17; Pl. 19, figs. 1, 2, 6, 11, 18, 19.

Remarks. Differs from *Canutus nitidus* by having tetragonal and irregularly polygonal (as well as triangular) pore frames on outer latticed layer.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80641 and all others are from GSC locality C-080577.

Canutus sp. A

Plate 3, figures 4, 9

Remarks. Differs from *Canutus tipperi* by having a more elongate test with small, irregularly polygonal pore frames in the outer layer.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen GSC 80640 and all other specimens from GSC locality C-080577.

Family HSUIDAE Pessagno and Whalen, 1982

Genus *Hsuum* Pessagno, 1977a

Type species. *Hsuum cuestaense* Pessagno, 1977a.

Hsuum mulleri ? Pessagno and Whalen

? *Hsuum mulleri* Pessagno and Whalen, 1982, p. 133, Pl. 5, figs. 6, 8, 9; Pl. 12, figs. 16, 17.

Remarks. Species queried because specimen is incomplete (cephalis and horn are missing). In all other respects form is identical to *Hsuum mulleri,* which is described from the lower Pliensbachian of the Maude Formation (= Fannin Formation of Cameron and Tipper, 1985), Maude Island. Rare.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island; GSC locality C-080577; specimen GSC 80647 is not illustrated.

Hsuum optimus n. sp

Plate 5, figure 6

Diagnosis. Test large, slender conical with short cylindrical horn. Chamber boundaries marked by rows of distinct elongate nodes. Pores small and circular.

Description. Test large, elongate conical, pointed apically with short, slender, cylindrical horn and as many as 11 post-abdominal chambers. Cephalis hemispherical and imperforate; all remaining chambers perforate, trapezoidal in outline. Chamber width increases gradually throughout entire test length; chamber height fairly constant. Test has inner layer of small, linearly arranged, square to rectangular pore frames; pores circular to subcircular. Outer layer consists, in the first three or four chambers, of discontinuous costae. In subsequent chambers, the surface is marked by nonlinear, elongate nodes at chamber joints.

Remarks. Differs from all other species of *Hsuum* in having elongate nodes (rather than raised costae) superimposed on the longitudinal bars of the inner latticed layer. Differs from *Hsuum* sp. B, in having a more conical shape with more numerous, closely spaced elongate nodes. Extremely abundant.

Etymology. Latin, *optimus* (adj.), best.

Measurements (µm).

	Holotype	Average of 14 specimens	Max.	Min.
Length (excluding horn)	346	293	346	210
Maximum width	190	165	190	125

Type locality. GSC locality C-080579. See Appendix 1.

Range. Zones 2 to 6: middle Toarcian to Aalenian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80674 (holotype) from type locality. Additional specimens found at GSC localities C-080581, C-080582, C-080583, C-080584, C-080585, C-080586, and C-080597.

Hsuum sp. aff. *H. belliatulum* Pessagno and Whalen

Plate 15, figure 3

aff. *Hsuum belliatulum* Pessagno and Whalen, 1982, p. 131, Pl. 7, figs. 7, 8, 12, 18, 22; Pl. 13, fig. 3.

Remarks. Differs from *Hsuum belliatulum* by having a test that is more subcylindrical than conical, with less continuous costae, larger pores, and a longer, stronger, tapering horn.

Range. Zones 6 and 7: Aalenian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80643 from GSC locality C-080586. Additional specimens collected at GSC localities C-080588 and C-080594.

Hsuum sp. cf. *H. mirabundum* Pessagno and Whalen

Plate 15, figure 4

cf. *Hsuum mirabundum* Pessagno and Whalen 1982, p. 131, Pl. 7, figs. 9, 17, 21.

Remarks. Specimens compare well with *Hsuum mirabundum*, but are slimmer and more elongate; indeed, some are one third as long again as the illustrated specimen. In addition, very few lateral costae have been noted.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80644 from GSC locality C-080595. Additional specimens collected at GSC localities C-080587, C-080593, and C-080594.

Hsuum sp. aff. *H. mirabundum* Pessagno and Whalen

Plate 17, figures 7, 8

aff. *Hsuum mirabundum* Pessagno and Whalen, 1982, p. 131, Pl. 7, figs. 9, 17, 21.

Remarks. Differs from *Hsuum mirabundum* in having a test that is longer and less pointed apically. In addition, pore frames are larger, and on distal portions there are three (not two) longitudinally aligned rows of pore frames between costae. A related hsuid form, (no. 2) Pl. 17, fig. 7 (GSC 80645), appears to be intermediate between (no. 1) *H.* sp. cf. *H. mirabundum* (Pl. 15, fig. 4) and (no. 3), the form described herein. Number 2 is the same shape as number 1, but has three rows of longitudinally aligned pore frames between costae, as does number 3. As all three occur together at various localities, they probably represent a single variable species.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80646 from GSC locality C-080595. Other specimens found at C-080588.

Hsuum sp. cf. *H. rosebudense* Pessagno and Whalen

Plate 5, figures 3-5

cf. *Hsuum rosebudense* Pessagno and Whalen, 1982, p. 134, Pl. 6, figs. 3, 14, 19; Pl. 12, fig. 14.

Remarks. Three variants of an extremely abundant form are illustrated, all of which have some affinity with *Hsuum rosebudense*. Collectively they differ in having more slender, elongate tests. When viewed with the binocular microscope, all variants display only minor differences with respect to length and width of test, but observation with the scanning electron microscope discloses distinct differences in shape and nature of costae as noted below.

Variant A (Pl. 5, fig. 3), subcylindrical and slender, costae are long and continuous (this variant most similar to *H. rosebudense*).

Variant B (Pl. 5, fig. 4), more elongate than variant A, costae less continuous with lateral branching.

Variant C (Pl. 5, fig. 5), test shorter and broader, distal chamber somewhat constricted. Costae discontinuous, some branching laterally.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimens GSC 80648 (variant A), GSC 80649 (variant B) and GSC 80650 (variant C), all from GSC locality C-080579.

Hsuum sp. A

Plate 5, figure 2

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80651 from GSC locality C-080579.

Hsuum sp. B

Plate 5, figures 7, 8

Remarks. This form has a more broadly conical shape than *Hsuum optimus* n. sp. In addition, the costae, although irregular, are more continuous.

Range. Zones 2 to 4: middle to late middle/early late Toarcian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80672 and 80673 from GSC locality C-080597. Single specimens collected at GSC localities C-080583 and C-080584.

Hsuum (?) sp. C

Plate 15, figure 5

Remarks. Differs from *Hsuum optimus* n. sp. in being smaller, with larger pores and a more massive horn.

Range. Zones 6 (?), 7: Aalenian (?), early Bajocian.

Occurrence. Phantom Creek (?) and Graham Island formations, Graham Island. Illustrated specimen GSC 80675 from GSC locality C-080594. Additional specimens found at GSC localities C-080586 (?) and C-080593.

Genus *Drulanta* Yeh, 1987

Type species. Drulanta mirifica Yeh, 1987.

Drulanta edenshawi n. sp.

Plate 2, figures 5, 6

Diagnosis. Test conical, rounded apically without horn. 9 to 12 strong, rounded longitudinal costae visible laterally between single rows of large circular to rectangular pores. Test has a "welded" appearance.

Description. Test elongate, conical, rounded apically without horn and usually with six or seven post-abdominal chambers. Cephalis hemispherical, all other chambers trapezoidal in outline. All but final one or two chambers increasing gradually in height and width; distal chambers on complete specimens slightly reduced in width. Some tests very slightly constricted at joints. Cephalis and thorax perforate, covered with a smooth layer of microgranular silica. Two rows of thin, circular to rectangular pore frames per chamber; pores circular to subcircular. Continuous costae strong, and rounded; superimposed on test between single longitudinal rows of coarse pores; 9 to 12 costae visible laterally. Test has a "welded" appearance.

Remarks. Drulanta edenshawi has more variable morphology than *D. mostleri* Yeh. It can have a shorter, stouter test that is very rounded apically as illustrated by the holotype (Pl. 2, fig. 5) as well as a more elongate test illustrated by the paratype (Pl. 2, fig. 6). It is generally larger than *D. mostleri* and has much coarser costae.

Etymology. Named for Albert Edward Edenshaw, a prominent chief of the Haida Indians whose head village was at Kiusta, later at Kung (both are located on the north coast of Graham Island).

Measurements (μm).

	Holotype	Average of 17 specimens	Max.	Min.
Length	296	290	350	210
Maximum width	148	149	170	112

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimens GSC 80653 (holotype) and GSC 80654 (paratype) from the type locality. Additional specimens at GSC locality C-080578.

Genus *Crubus* Yeh, 1987

Type species (by subsequent designation). *Crubus chengi* Yeh, 1987, p. 69, Pl. 18, figs. 13-15, 19-20, 24; Pl. 20, figs. 7, 15.

Remarks. Yeh (1987) designated *Crubus robustus* Yeh, 1987 as the type species for the genus *Crubus*. However, in the original description of this species and in all Yeh's subsequent references to this taxon, the binomial name appears as *Crubus* (?) *robustus*. In the original description Yeh states "this species is questionably assigned to *Crubus* n. gen. because it lacks a horn". Querying generic assignment of a type species effectively invalidates that species as type (see Article 67C, ICZN, 1985). A new type species is herein designated that more clearly conforms to the generic description and is better documented.

Crubus wilsonensis n. sp

Plate 5, figure 12

Diagnosis. Test large, broadly conical with short horn. Eighteen costae visible laterally; three longitudinally aligned pores per chamber between adjacent costae. Ridges slightly raised with small nodes superimposed on costae.

Description. Test broadly conical, rounded apically with short cylindrical horn. Cephalis hemispherical, all other chambers trapezoidal in outline. Cephalis imperforate, thorax and abdomen sparsely perforate; all three covered with a layer of microgranular silica. Usually 7 to 9 postabdominal chambers. All but final chamber increase gradually in width and height. Fifteen continuous narrow costae visible laterally, nodose along ridges. Single rows of longitudinally aligned pores (three per chamber, set in square pore frames) alternate with costae.

Remarks. Differs from *Crubus firmus* Yeh in having three rows of linearly arranged pore frames per chamber, larger pores on initial chambers, a stouter horn, and stronger costae.

Etymology. Named for Wilson Creek on Graham Island, site of one of the early coal mines.

Measurements (μm).

	Holotype	Average of 10 specimens	Max.	Min.
Length (excluding horn)	334	290	334	210
Maximum width	188	171	190	155

Type locality. GSC locality C-080579. See Appendix 1.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Illustrated specimen GSC 80656 (holotype) and paratypes from the type locality. A further specimen was collected at GSC locality C-080593.

Genus *Lupherium* Pessagno and Whalen, 1982

Type species. Lupherium snowshoense Pessagno and Whalen, 1982.

Lupherium sp. A

Lupherium sp. A, Pessagno and Whalen, 1982, p. 136, Pl. 6, fig. 4.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Specimens collected from GSC localities C-080579, C-080589, C-080595, and C-80597. Specimen GSC 80652 (not illustrated) from GSC locality C-080579. Pliensbachian of California (Franciscan Complex) and east-central Oregon (Nicely Formation): see Pessagno and Whalen (1982).

Lupherium (?) sp. B

Plate 5, figure 11;
Plate 13, figures 5, 10, 12

Remarks. Similar to *Lupherium* sp. G (Yeh, 1987, p. 68, Pl. 23, fig. 5) but apical chambers of test are less attenuated, the distal chamber is more constricted and the horn (?) is less distinct.

Range. Zones 2 to 5: middle to late Toarcian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek Formation, Graham Island. Illustrated specimens GSC 80655 and GSC 80758 from GSC localities C-080579 and C-080583, respectively. Other specimens collected at GSC localities C-080582, C-080584, C-080585 and C-080597.

Family THEOPERIDAE Haeckel, 1881, emend. Riedel, 1967b

Genus *Protounuma* Ichikawa and Yao, 1976

Type species. Protounuma fusiformis Ichikawa and Yao, 1976.

Protounuma paulsmithi n. sp

Plate 6, figures 9, 12

Diagnosis. Spindle-shaped, inflated, lacking horn. Base partially constricted; aperture half of maximum diameter of test. Test surface has ten to fourteen longitudinal plicae, with two to three longitudinal rows of circular pores between flanking plicae.

Description. Test spindle-shaped, multisegmented, final chamber partially constricted at base, aperture half of maximum diameter of test. Apical horn lacking on all specimens examined. Cephalis small and imperforate. All chambers, except for the final one or two, increase rapidly in width; final chamber(s) slightly constricted. Ten to fourteen longitudinal plicae superimposed on surface of test; plicae mostly continuous from thorax to aperture. Two to three longitudinal rows of circular pores between adjacent plicae. Pores usually arranged diagonally, but sometimes horizontally. Pore size increases very slightly from apex to base.

Remarks. This species is larger than *Protounuma fusiformis* Ichikawa and Yao, has a larger aperture, fewer plicae and larger pores; but like *P. fusiformis* it too is quite variable, having both short broad forms and more elongate 'slender' ones. Differs from *P. costata* (Heitzer) in having a larger terminal aperture, fewer rows of pores between adjacent plicae, and these pores are larger.

Etymology. Named in honour of Dr. P.L. Smith, of the University of British Columbia, for his contributions to the study of Jurassic ammonite biostratigraphy.

Measurements (µm).

	Holotype	Average of 19 specimens	Max.	Min.
Maximum length	216	179	216	130
Maximum width	121	107	121	98

Type locality. GSC locality C-080579. See Appendix 1.

Range. Zones 2 to 5: middle to late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands, respectively. Illustrated specimen GSC 80657 (holotype) from the type locality. Single specimen collected at GSC locality C-080597.

Family PARVICINGULIDAE Pessagno, 1977a, emend. Pessagno and Whalen, 1982

Genus *Parvicingula* Pessagno, 1977a

Type species. Parvicingula santabarbaraensis Pessagno, 1977a.

Remarks. Parvicingula is interpreted in the sense of Baumgartner (1984), that is it includes "forms without or with weakly developed horn, which otherwise fit Pessagno's (1977a) definition".

Parvicingula aculeata n. sp.

Plate 18, figures 1, 2, 7

Diagnosis. Test subcylindrical with 10 or more post abdominal chambers and very short, slender horn. Test has rows of pointed nodes in place of circumferential ridges between abdomen and first few post-abdominal chambers.

Description. Test elongate, subcylindrical with 10 or more post-abdominal chambers when well preserved. Cephalis small, conical with very short, slender horn (not visible on all specimens). Thorax, abdomen and first few post-abdominal chambers trapezoidal, remaining chambers subrectangular in outline. Cephalis and thorax sparsely perforate. Post-abdominal chambers have three lateral rows of symmetrical (predominantly pentagonal) pore frames between ridges. Pore frames in rows flanking circumferential ridges slope steeply away from ridges. Those in central row depressed, smaller and staggered; pores elliptical. Test has rows of sharp pointed nodes, rather than discrete circumferential ridges, between abdomen and first three or four post-abdominal chambers. More distal ridges are narrow with small rounded nodes.

Remarks. Differs from all other species of *Parvicingula* by having a very short, almost non-existent, horn and sharp pointed nodes separating the abdomen and first few post-abdominal chambers.

Etymology. Latin, *aculeatus* (adj.), prickly.

Measurements (µm).

	Holotype	Average of 7 specimens	Max.	Min.
Length (excluding horn)	321	308	346	260
Maximum width	126	116	130	109

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80664 (holotype) and GSC 80665 (paratype) from the type locality. Other specimens collected at GSC localities C-080579, C-080584, C-080587, C-080588, C-080591, C-080593 and C-080594.

Parvicingula boesii (Parona) group

Plate 6, figure 4

Dictyomitra boesii Parona, 1890, p. 170; Pl. 6, fig. 9.

Dictyomitra boesii Parona. Foreman, 1975, p. 613; Pl. 2H, figs. 10, 11; Pl. 7, fig. 9.

Parvicingula boesii (Parona). Pessagno, 1977b, p. 48; Pl. 8, fig. 5.

Mirifusus boesii (Parona). Foreman, 1978, p. 746; Pl. 2, fig. 6.

Parvicingula boesii (Parona) group: Baumgartner, De Wever, and Kocher, 1980, p. 58; Pl. 5, fig. 15; Pl. 6, fig. 8.

Remarks. This species is interpreted in the sense of Baumgartner, De Wever, and Kocher (1980). Although it has many features in common with morphotypes of the *Parvicingula boesii* group, it has fewer post-abdominal chambers, coarser, less regular pore frames, and may therefore be an ancestral form. Very abundant in middle Toarcian deep water assemblages.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Illustrated specimen GSC 80687 from GSC locality C-080579. Additional specimens found at GSC localities C-080588, C-080589, C-080594, and C-080595.

Parvicingula matura Pessagno and Whalen

Plate 18, figures 6, 12, 16

Parvicingula matura Pessagno and Whalen, 1982, p. 139; Pl. 7, figs. 1-3, 15, 19, 20; Pl. 13, fig. 1.

Remarks. Form varies in development of circumferential ridges. Illustrated specimen has rows of small nodes at chamber boundaries, and other specimens have weakly developed ridges. As with other species, the earlier individuals seem to have coarser pores and fewer of them. Abundant in all early Bajocian samples.

Range. Zones 4 (?), 7: late middle/early late Toarcian (?), early Bajocian.

Occurrence. Phantom Creek (?) and Graham Island formations, Graham Island. Illustrated specimen GSC 80658 from GSC locality C-080595. Additional specimens collected at GSC localities C-080583 (?), C-080588, C-080589, C-080592, C-080593 and C-080594. Snowshoe Formation of east-central Oregon; subsurface of Alaska: see Pessagno and Whalen (1982).

Parvicingula sp. aff. *P. burnensis* Pessagno and Whalen

Plate 18, figures 8, 10, 15

aff. *Parvicingula burnensis* Pessagno and Whalen, 1982, p. 137; Pl. 9, figs. 5-7, 14, 15, 19, 20; Pl. 13, fig. 2.

Remarks. This species resembles *Parvicingula burnensis* Pessagno and Whalen but differs in being larger (length 310-430 μm; width 130-160 μm in 7 specimens), having less well developed circumferential ridges, and having coarse, somewhat less regular meshwork.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80659 and 80660 from GSC localities C-080588 and C-080594, respectively. Additional specimens collected at GSC localities C-080579, C-080597 and C-080593.

Parvicingula sp. aff. *P. media* Pessagno and Whalen

Plate 18, figures 9, 11

aff. *Parvicingula media* Pessagno and Whalen, 1982, p. 139; Pl. 9, figs. 3, 4, 17, 21; Pl. 13, fig. 6.

Remarks. This species closely resembles *Parvicingula media* Pessagno and Whalen, but test is more slender and tapering, with a longer horn. Ridges between early chambers nodose, but nodes less well developed than on *P. media*.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80662 from GSC locality C-080595. Additional specimens found at GSC localities C-080579, C-080586, C-080587, C-080589, and C-080594.

Parvicingula sp. aff. *P. profunda* Pessagno and Whalen

Plate 18, figures 13, 14

aff. *Parvicingula profunda* Pessagno and Whalen 1982, p. 140; Pl. 10, figs. 3-6, 14, 15, 18, 19; Pl. 13, fig. 7.

Remarks. This form differs from *Parvicingula profunda* Pessagno and Whalen in having a test that is less inflated distally (subcylindrical rather than conical in shape) and by having narrower circumferential ridges. *Parvicingula profunda* is known from the upper Bathonian part of the Snowshoe Formation of east-central Oregon.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80633 from GSC locality C-080595. Additional specimens collected at GSC localities C-080588, C-080590 and C-080593.

Parvicingula (?) sp. A

Plate 5, figure 1

Remarks. This form appears to be related to *Parvicingula matura* Pessagno and Whalen but differs in having smaller nodes separating earliest post-abdomional chambers; coarser and less symmetrically arranged pore frames and wider circumferential ridges between distal post-abdominal chambers. The knob on top is probably the cephalis rather than a horn – this cannot be checked, as all specimens are pyritized.

According to Pessagno and Whalen (1982), *P. matura* is one of the earliest species of *Parvicingula* s.l. to appear; indicated range is Aalenian to middle early Bajocian. No middle or upper Toarcian samples were included in their study; Toarcian material however, constitutes a major portion of this study and thorough examination discloses abundant forms very similar to *P. matura* in a middle Toarcian sample. Again it should be noted that these forms have fewer, coarser pores than the later members of the species. This species is probably a form ancestral to true *Parvicingula.*

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80661 from GSC locality C-080579.

Parvicingula sp. B

Plate 18, figures 3, 4

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimens GSC 80666 and 80667 from GSC locality C-080595. Additional specimens collected at GSC localities C-080587, C-080589, C-080592, C-080593, and C-080594.

Parvicingula sp. C

Plate 18, figure 5

Range and Occurrence. Zone 7: early Bajocian of Graham Island Formation, Graham Island. Specimens collected at GSC localities C-080588, C-080592, C-080594 and C-080595. Rare. Illustrated specimen GSC 80668 from GSC locality C-080595.

Parvicingula sp. D

Plate 15, figures 1, 2

Range. Zones 6 and 7: Aalenian to early Bajocian.

Occurrence. Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80669 from GSC locality C-080586. Other specimens collected at GSC localities C-080594 and C-080595.

Parvicingula sp. E

Plate 5, figure 13

Remarks. Bears some resemblance to *Parvicingula* (*Ristola*) *decora*, but is more gradually conical, less annulate, has more post-abdominal chambers and has less massive nodes on ridges.

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80670 and all additional specimens from GSC locality C-080579.

Parvicingula sp. F

Plate 17, figure 11

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Rare. Illustrated specimen GSC 80671 from GSC locality C-080594. One additional specimen collected at GSC locality C-080592.

Genus *Elodium* n. gen.

Type species. Elodium cameroni n. sp.

Description. Test conical and large, with well developed horn and numerous closely spaced post-abdominal chambers separated by nodose circumferential ridges. Three rows of longitudinally aligned circular to subcircular pores in polygonal (mostly tetragonal) pore frames, between circumferential ridges. Lateral pore rows flanking ridges slope steeply away from ridges. Post-abdominal chambers constricted between ridges. Pores in constricted area may be irregular to absent on distalmost chambers of test. Cephalis and thorax sparsely perforate to imperforate, covered with outer layer of microgranular silica; this covering may extend onto earliest post-abdominal chambers.

Remarks. Elodium n. gen. possesses three rows of primary (open) pores between circumferential ridges; it differs from *Parvicingula* Pessagno in that these pores are longitudinally aligned rather than offset.

Etymology. Elodium is formed by an arbitrary combination of letters (ICZN, 1985, Appendix D, Pt. VI, Recommendation 40, p. 201).

Range. Early to Middle Jurassic: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island, Queen Charlotte Islands.

Elodium cameroni n. sp.

Plate 13, figures 1, 2, 6, 9

Diagnosis. Large conical-cylindrical test with 10 to 14 post-abdominal chambers and a strong asymmetric apical horn. All pores large, primary and circular; three rows on proximal chambers, two rows on distalmost chambers.

Description. Test large with 10 to 14 strongly constricted post-abdominal chambers separated by nodose circumferential ridges; nodes low and rounded. Cephalis and thorax trapezoidal in external outline, partially perforate, covered by veneer of microgranular silica. Cephalis has strong, asymmetric apical horn. All pores on post-abdominal chambers circular and primary (open); those within constricted areas smaller, disappearing on distalmost chambers. Earliest post-abdominal chambers trapezoidal, increasing gradually in width and height, distal chambers almost cylindrical with slight decrease in height.

Remarks. *Elodium cameroni* is compared to *E. nadenensis* n. sp., under the latter. *Elodium cameroni* is very abundant, in all middle/upper Toarcian samples.

Etymology. This species is named in honour of B.E.B. Cameron for his important contribution to the Mesozoic stratigraphy and foraminiferal biostratigraphy of the Queen Charlotte Islands, B.C.

Measurements (μm).

	Holotype	Average of 20 specimens	Max.	Min.
Length (excluding horn)	369	352	450	280
Maximum width	161	159	185	147

Type locality. GSC locality C-080597. See Appendix 1.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80631 (holotype) and GSC 80632 (paratype) from type locality. Additional specimens collected at GSC localities C-080581, C-080582, C-080583, C-080584, C-080585 and C-080586.

Elodium nadenensis n. sp.

Plate 13, figures 3, 8, 11

Diagnosis. Test elongate, conical, produced apically into a short horn. Initial chambers imperforate, nodose, covered with dense layer of microgranular silica. Ridges wide and rounded, marked by elongate nodes.

Description. Test elongate, conical, apex pointed, with short, well developed horn. Cephalis, thorax and abdomen (?) imperforate; covered with heavy coating of microgranular silica; boundaries indistinguishable. Pores on abdomen (?) and first post-abdominal chamber/chambers relict, these too are covered with microgranular silica. As many as 12 moderately constricted post-abdominal chambers are separated by wide, rounded circumferential ridges marked by elongate nodes. Three rows of longitudinally aligned to subaligned pores between ridges. Pores circular to subcircular in rows adjacent to ridges; pores in constricted area are smaller, mostly elliptical, and become more irregularly arranged on distal chambers. On complete tests, final chamber may be somewhat constricted.

Remarks. Differs from *Elodium cameroni* n. sp. by having a more conical, apically pointed test with a heavier coating of microgranular silica. In addition, the horn is shorter, more symmetrical and circumferential ridges are wider and more rounded. Differs from *Lupherium* (?) sp. B by having more prominent circumferential ridges. Abundant.

Etymology. Named for Naden Harbour on the north coast of Graham Island.

Measurements (μm).

	Holotype	Average of 15 specimens	Max.	Min.
Length (excluding horn)	294	301	380	220
Maximum width	117	131	142	117

Type locality. GSC locality C-080581. See Appendix 1.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80633 (holotype) from the type locality. Additional specimens found at GSC localities C-080582, C-080583, C-080584, C-080586, and C-080597.

Elodium (?) sp. A

Plate 13, figures 4, 7

Remarks. Genus queried because of development of weak "costae" between longitudinal rows of pores. *Elodium* (?) sp. A differs from *E. nadenensis* n. sp. by virtue of being much less pointed apically, having more uniformly sized pores and by developing weak costae. Rare.

Range. Zones 3 to 5: late middle to late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80634 from GSC locality C-080581. One additional specimen collected from GSC locality C-080597.

Family ULTRANAPORIDAE Pessagno, 1977b

Genus *Jacus* De Wever, 1982

Type species. *Jacus coronatus* De Wever, 1982.

Jacus magnificus n. sp

Plate 6, figure 10

Diagnosis. Robust form with massive, sharply pointed horn and three long, slightly curved, triradiate feet. Mouth distinctly triangular. Thorax has two to four lateral rows of mostly tetragonal pore frames.

Description. Robust form with massive horn and long, slightly curved, triradiate feet. Cephalis knob-shaped, bearing a long, pointed horn. Two thirds down length of horn below tip, are nine small node-like protrusions arranged in three horizontal groups of three. Each group is separated from the next by a deep narrow groove, but the three protrusions within each group alternate with a pair of shallow grooves. Thorax trapezoidal, strongly triangular in transverse section. Three pronounced ridges are superimposed on thorax extending from base of cephalis to tips of feet. Cephalis and thorax covered with coarse, irregularly polygonal pore frames; those on thorax are larger, mostly tetragonal and arranged in four to six lateral rows concentric with base of thorax. Remnants of a velum may be seen around distal edge of thorax on well preserved specimens.

Remarks. Differs from all other described species of *Jacus* by its strong triangularity and downward curving lateral thoracic costae.

Etymology. Latin, *magnificus* (adj.), noble, eminent, splendid.

Measurements (μm).

	Holotype	Average of 8 specimens	Max.	Min.
Height of cephalis and horn	138	120	138	100
Width of cephalis	79	69	79	60
Height of thorax	84	107	152	84
Width of thorax	157	152	162	130
Length of feet	88	113	130	88

Type locality. GSC locality C-080579. See Appendix 1.

Range. Zones 1 and 2: late Pliensbachian to middle Toarcian.

Occurrence. Fannin and Whiteaves formations, Maude Island. Illustrated specimen GSC 80676 (holotype) and all other specimens from the type locality. Single specimen from GSC locality C-080577 destroyed during SEM photography.

Jacus sp. A

Plate 6, figure 7

Range. Zone 2: middle Toarcian.

Occurrence. Whiteaves Formation, Maude Island. Illustrated specimen GSC 80678 from GSC locality C-080579.

Genus *Napora* Pessagno, 1977a

Type species. Napora bukryi Pessagno, 1977a.

Napora browni Pessagno, Whalen, and Yeh

Napora browni Pessagno et al. (1986, p. 101, Pl. 6, figs. 9, 10).

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. GSC locality C-080583. Warm Springs Member, Snowshoe Formation, east-central Oregon: see Pessagno et al., 1986.

Napora horrida Pessagno, Whalen, and Yeh

Napora horrida Pessagno et al. (1986, p. 87, Pl. 6, figs. 16, 20).

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. GSC localities C-080587 and C-080588. Warm Springs Member, Snowshoe Formation, east-central Oregon: see Pessagno et al. (1986).

Napora insolita Pessagno, Whalen, and Yeh

Napora insolita Pessagno et al. (1986, p. 88, Pl. 5, figs. 5, 12, 13).

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. GSC locality C-080584. Warm Springs Member, Snowshoe Formation, east-central Oregon: see Pessagno et al. (1986).

Napora turgida Pessagno, Whalen, and Yeh

Napora turgida Pessagno et al. (1986, p. 101, Pl. 6, figs. 9, 10).

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek formation, Graham Island. GSC localities C-080584 and C-080585. Warm Springs Member, Snowshoe Formation, east-central Oregon: see Pessagno et al. (1986).

Napora sp. aff. *N. cosmica*
Pessagno, Whalen, and Yeh

Plate 14, figure 2

Napora sp. aff. *N. cosmica* Pessagno et al. (1986, p. 82, Pl. 6, fig. 8).

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80679 from GSC locality C-080584. Additional specimens collected at GSC localities C-080583 and C-080584. ? Aalenian; Warm Springs Member, Snowshoe Formation; east-central Oregon: see Pessagno et al. (1986).

Napora sp. aff. *N. turgida*
Pessagno, Whalen, and Yeh

Plate 14, figure 1

aff. *Napora turgida* Pessagno et al. (1986, p. 101, Pl. 6, figs. 9, 10).

Remarks. Differs from *Napora turgida* in having a longer horn.

Range. Zones 1 to 5: late Pliensbachian to late Toarcian.

Occurrence. Fannin Formation, Maude Island; Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80677 from GSC locality C-080583. Other specimens collected at GSC localities C-080577, C-080579, C-080581, C-080584, and C-080597. Warm Springs Member, Snowshoe Formation, east-central Oregon: see Pessagno et al. (1986).

Family FARCIDAE Pessagno, Whalen, and Yeh

Genus *Rolumbus* Pessagno, Whalen, and Yeh, 1986

Type species. Rolumbus mirus Pessagno, Whalen, and Yeh, 1986.

Rolumbus kiustaense n. sp.

Plate 14, figure 4

Diagnosis. Hemispherical dicyrtid with two stout, subequal, asymmetrical apical horns and four slender triradiate feet that extend obliquely outward from base of thorax.

Description. Cephalis spherical and imperforate with two short, stout, triradiate apical horns. Horns are subequal in length and asymmetrical (one arises more apically than the other). Thorax hemispherical, surface covered with irregularly sized, mostly circular pores. Basal aperture large and circular. Four long, slender, triradiate feet extend outward obliquely from near base of thorax.

Remarks. Differs from ***Rolumbus mirus*** Pessagno, Whalen, and Yeh in having a wider thorax, more widely spread feet and longer apical horns.

Etymology. Named for the old Haida village of Kiusta, in the northwest corner of Graham Island.

Measurements (µm).

	Holotype	Average of 8 specimens	Max.	Min.
Height of cephalis and thorax	152	131	152	110
Width of thorax	142	142	150	130
Length of longest horn	50	64	120	45

Type locality. GSC locality C-080583. See Appendix 1.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80681 (holotype) from the type locality. Additional specimens from GSC localities C-080582, C-080584, and C-080585.

Family EPTINGIIDAE Dumitrica, 1978

Genus *Protoperispyridium* Yeh, 1987

Type species. Protoperispyridium oregonense Yeh, 1987.

Protoperispyridium hippaensis n. sp.

Plate 6, figures 1, 2

Protoperispyridium sp. A, Yeh, 1987, p. 93, Pl. 13, figs. 13, 20.

Diagnosis. Strongly triangular, thickened peripheral shell with concave sides, heavy nodes and prominent sleeve-like extensions. Three spines are massive and triradiate with crown-like extensions (produced by subsidiary spines on ridge tips).

Description. Cephalis indistinct, peripheral shell triangular in outline, sides concave; shell thickened at right angles to frontal plane. Apical and two primary lateral spines often not at 120°. Spines massive, triradiate with alternating ridges and grooves. Ridges wide and deep, grooves relatively shallow, merging to a point. Outer tip of each ridge is widened and blunt. The subsidiary spines together produce a crown-like structure.

Remarks. Differs from *Protoperispyridium* sp. B, in having a thicker shell with concave sides, more massive pore frames and heavier nodes.

Etymology. Named for Hippa Island, on the west coast of Graham Island.

Measurements (µm).

	Holotype	Average of 10 specimens	Max.	Min.
Width of test (along spine axis)	120	130	150	112
Length of longest spine	93	96	110	82

Type locality. GSC locality C-080588. See Appendix 1.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Illustrated specimens GSC 80683 (holotype) from type locality; GSC 80684 (paratype) from GSC locality C-080579. Additional specimens have been collected at GSC localities C-080597, C-080589, C-080593, and C-080595. Species is abundant only at GSC locality C-080579 (middle Toarcian).

Genus *Perispyridium* Dumitrica, 1978

Type species. Trilonche (?) ordinaria Pessagno, 1977b.

Perispyridium ? sp. A

Plate 4, figure 7

Remarks. Genus queried because poor preservation (pyrite) prohibits clear observation of morphology. However, test shape and disposition of spines suggest an ancestral form of *Perispyridium*.

Range. Zones 2 to 4: middle to late middle/early late Toarcian.

Occurrence. Whiteaves and Phantom Creek formations, Maude and Graham islands. Illustrated specimen GSC 80594 from GSC locality C-080579.

Perispyridium sp. B

Plate 15, figure 6

Remarks. Differs from *Perispyridium gemmatum* Pessagno and Blome in having a strongly triangular shell with sleeve-like extensions and longer, more massive spines. Differs from *P. alinchakense* Pessagno and Blome in having stronger nodes, wider sleeve-like extensions and more massive spines with pointed, rather than blunt, tips.

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80682 from GSC locality C-080595. Additional specimens collected at GSC localities C-080589, C-080593, and C-080594.

Family EUCYRTIDIIDAE Ehrenberg, 1847

Genus *Eucyrtidiellum* Baumgartner, 1984

Type species. Eucyrtidium (?) unumaensis Yao, 1979.

Eucyrtidiellum sp. aff. *E. unumaensis* (Yao)

aff. *Eucyrtidium* (?) *ptyctum* Riedel and Sanfilippo, 1974, p. 778, Pl. 12, fig. 15. Baumgartner and Bernoulli, 1976, fig. 11f.

aff. *Eucyrtidium* (?) *unumaensis* Yao, 1979, p. 39, Pl. 9, figs. 1-11. Kocher, 1981, p. 67, Pl. 13, fig. 15. Yao et al., 1982, Pl. 3, fig. 7. Sashida et al., 1982, Pl. 2, fig. 3. Kojima, 1982, Pl. 1, fig. 11. Wakita, 1982, Pl. 3, fig. 1k. Matsuoka, 1982, Pl. 1, fig. 15. Wakita and Okamura, 1982, Pl. 8, fig. 7. Saka, 1983, Pl. 5, figs. 6, 7.

aff. *Eucyrtidiellum unumaensis* (Yao), Baumgartner, 1984, p. 765, Pl. 4, fig. 6.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Rare specimens found at GSC localities C-080579 and C-080591. Inuyama area, Gifu and Aichi prefectures, Japan: see Yao (1979). Specimen GSC 80685 from GSC locality C-080579.

Genus *Eucyrtidium* Ehrenberg, 1847

Type species. Lithocampe acuminata Ehrenberg, 1844.

Eucyrtidium elementarius n. sp.

Plate 17, figure 13

Diagnosis. Ovate, smooth multicyrtid with thick-walled test (at least two layers), and medium-sized symmetrical horn.

Description. Test ovate, usually with six to eight post-abdominal chambers, and a medium-sized symmetrical horn. Boundaries between initial chambers indistinct; distal chambers separated by slightly thickened ridges and/or lateral rows of small, poorly developed nodes. All chambers separated internally by planiform partitions with circular apertures. Apical chambers increase rapidly in width; intermediate chambers are cylindrical; final chamber always slightly constricted. Height of all chambers appears to be constant. Test walls thick, composed of at least two (and likely more) layers of pores set in hexagonal pore frames. Pores circular on outer layer; small on proximal chambers, becoming larger and more uniform in size on distal chambers.

Remarks. This form bears no resemblance to any known species of *Eucyrtidium*. Specimens (not illustrated) of middle Toarcian age are very similar (possibly ancestral ?) to this species, but differ in having a greater number of post-abdominal chambers and coarser meshwork with smaller, more irregularly arranged pore frames.

Etymology. Latin, *elementarius* (adj.), pertaining to rudiments and first principles.

Measurements (μm).

	Holotype	Average of 17 specimens	Max.	Min.
Maximum length (excluding horn)	244	287	350	230
Maximum width	144	153	170	135
Length of horn	38	28	40	20

Type locality. GSC locality C-080595. See Appendix 1.

Range. Zones 2 (?); 7: middle Toarcian (?); early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Illustrated specimen GSC 80686 (holotype) from type locality. Additional specimens collected at GSC localities C-080593 and C-080594. Middle Toarcian specimens (not illustrated) from GSC locality C-080579. Abundant at all localities.

Eucyrtidium (?) sp. A

Plate 17, figure 14

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80688 from GSC locality C-080592. Single specimens collected at GSC localities C-080588 and C-080595.

Genus *Katroma* Pessagno and Poisson, 1981, emend. De Wever, 1982

Type species. Katroma neagui Pessagno and Poisson, 1981.

Katroma ninstintsi n. sp.

Plate 2, figures 4, 9

Katroma sp. Igo et al., 1985, Pl. 15, fig. 4.

Katroma sp. A Yeh, 1987, p. 81, Pl. 3, fig. 1; Pl. 6, figs. 4, 14.

Diagnosis. Tricyrtid test; abdomen expanded and globose with long, open tubular extension. Apical horn small and asymmetrical.

Description. Tricyrtid test: cephalis small and hemispherical; thorax trapezoidal, expanding more rapidly in height than width; abdomen enlarged and globose, terminating in an open tubular extension. Irregularly shaped pore frames small on initial chambers, becoming larger on expanded portion of abdomen and decreasing in size on tubular extension. Apical horn small and more or less asymmetrical. On some specimens this horn appears to divide in the manner of *Katroma neagui* Pessagno and Poisson (see Pl. 2, fig. 9, this report). Lateral spine (V-spine) present, but very short and usually broken in type material. Very small, radial spines (positioned at maximum extension of abdomen) are more often than not eroded.

Remarks. A number of forms are tentatively grouped together as *Katroma ninstintsi;* they are thought to represent variants of one species. Collectively they differ in exhibiting a more or less abrupt transition from expanding thorax to inflated abdomen. This change is sometimes quite distinct (see Pl. 2, fig. 9) in other cases not (holotype, Pl. 2, fig. 4).

Katroma ninstintsi normally differs from *K. bicornis* De Wever in having only one very small, asymmetrical apical horn, and the radial abdominal spines are much smaller. It differs from *K. neagui* Pessagno and Poisson in having a more expanded abdominal chamber and, whereas the apical horn on some specimens appears to divide, it is much shorter and usually has only two, rather than four, radial branches.

Etymology. Named for Haida Indian Chief Ninstints, of Anthony Island.

Measurments (μm).

	Holotype	Average of 13 specimens	Max.	Min.
Length of apical horn	15	22.3	61	14
Length of cephalis and thorax	46	85	105	46
Length of abdomen	96	120	150	92
Length of terminal tube	106	144	170	120
Maximum width of abdomen	107	155	200	107

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude and Graham islands. Illustrated specimens GSC 80694 (holotype) and GSC 80695 (paratype) from type locality. Additional specimens collected at GSC locality C-080580.

Family PYLENTONEMIDAE Deflandre, 1963

Subfamily POULPINAE De Wever, 1981a

Genus *Bipedis* De Wever, 1982

Type species. Bipedis calvabovis De Wever, 1982

Bipedis fannini n. sp.

Plate 2, figures 7, 8

Diagnosis. Dicyrtid with small cephalis, globose thorax with roughened surface, long triradiate horn and two downward curving terminal feet.

Description. Bilaterally symmetrical dicyrtid test. Cephalis medium-sized, spherical, sparsely perforate basally with long, tapering apical horn. Horn triradiate with deep grooves on basal half. Thorax large and globose with constricted circular aperture and two strong, triradiate downward curving terminal feet. Thorax with roughened surface composed of low nodes or tubercles surrounded by small circular to elliptical pores.

Remarks. This species appears to be entirely new and differs significantly from all other known species of *Bipedis.* Rare at type locality, abundant in older Pliensbachian samples.

Etymology. Named in honour of John Fannin, curator of the provincial museum in Victoria, British Columbia, in the late 1800's.

Measurements (μm).

	Holotype	Average of 9 specimens	Max.	Min.
Height of cephalis and thorax	132	148	170	132
Maximum width of thorax	139	121	140	120
Length of apical horn	60	62	70	52
Length of feet	-	105	120	75

Type locality. GSC locality C-080577. See Appendix 1.

Range. Zone 1: late Pliensbachian.

Occurrence. Fannin Formation, Maude Island. Illustrated specimen (holotype) GSC 80702 from type locality.

Genus *Poulpus* De Wever, 1979

Type species. Poulpus piabyx De Wever, 1979.

Poulpus (?) sp.

Plate 2, figures 10, 11

Remarks. Single nodose specimen is tentatively assigned to *Poulpus.* It has a triradiate horn and three (one broken off) triradiate spine-like feet with weak subsidiary spines at distal ends of ridges. Further description must await collection of additional specimens.

Range and Occurrence. Zone 1: late Pliensbachian of Fannin Formation, Maude Island. Ilustrated specimen GSC 80689 from GSC locality C-080577.

SPONGOCAPSULIDAE **incertae sedis**

Remarks. Assignment of *Maudia* n. gen to the Spongocapsulidae Pessagno is questionable because *Maudia* apparently lacks septal platforms separating post-abdominal chambers from each other. According to Pessagno (1977a) these partitions are characteristic of the Spongocapsulidae, which to date represent the only family of spongy nassellarians.

Genus *Maudia* n. gen.

Type species. Maudia yakounense n. sp.

Description. Conical test with thick spongy wall and long horn. Test probably has multiple chambers, but these are not visibly divided, and lack septal partitions. Details of internal structure unknown.

Remarks. Maudia n. gen. differs from *Spongocapsula* by possessing an apical horn and lacking septal partitions.

Etymology. Named for Maude Island in Skidegate Inlet: a classic area for the study of Jurassic biostratigraphy.

Range. Late Early Jurassic.

Occurrence. Phantom Creek Formation, Queen Charlotte Islands, B.C.

Maudia yakounense n. sp.

Plate 14, figure 9

Diagnosis. Elongate conical test with thick spongy walls and a long slender horn.

Description. Test elongate conical with a thick, porous spongy wall composed of minute, irregularly polygonal pore frames. Cephalis dome-shaped, with a long, slender, needle-like horn. Remaining chambers trapezoidal in outline, but thick wall obscures chamber boundaries. Apertural edges of all tests are ragged, and probably broken, thus knowledge of complete test is unknown at this time.

Etymology. Named for the Yakoun River, Graham Island.

Measurements (μm).

	Holotype	Average of 11 specimens	Max.	Min.
Length (excluding horn)	300	222	300	170
Maximum width	220	164	220	130
Length of horn	85	95	120	80

Type locality. GSC locality C-080585. See Appendix 1.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80690 (holotype) from the type locality. Additional specimens collected at GSC localities C-080582, C-080583, and C-080584.

NASSELLARIINA **incertae sedis**

Genus *Lithomelissa* Ehrenberg, 1847

Type species. Lithomelissa micropteria Ehrenberg, 1854.

Lithomelissa sp. A

Plate 14, figure 5

Range. Zone 5: late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80703 from GSC locality C-080597.

Genus *Stichocapsa* Haeckel, 1882

Type species. Stichocapsa jaspidea Rüst, 1885.

Stichocapsa sp. cf. *S. convexa* Yao

Plate 6, figures 5, 6

cf. *Stichocapsa convexa* Yao, 1979, p. 35, Pl. 5, figs. 14-16; Pl. 6, figs. 1-7. Kocher, 1981, p. 95, Pl. 16, figs. 21-22. Wakita, 1982, Pl. 3, fig. 7. Aita, 1982, Pl. 1, figs. 6-7b.

cf. *Stichocapsa* sp. J., Aita, 1982, Pl. 1, figs. 8-9b.

Remarks. Form is very similar to *Stichocapsa convexa* but the dense row of pores at proximal part of thorax has not been noted. Abundant in all deeper water assemblages.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Illustrated specimens GSC 80691 and 80692 from GSC localities C-080579 and C-080593, respectively. Additional specimens found at GSC localities C-080588, C-080589, C-080590, C-080592, C-080594, C-080595, and C-080596.

Stichocapsa sp. aff. *S. japonica* Yao

Plate 15, figure 7

aff. *Stichocapsa japonica* Yao, 1979, p. 36, Pl. 6, figs. 8-12; Pl. 7, figs. 1-15. Kocher, 1981, p. 96, fig. 23. Yao et al., 1982, Pl. 3, fig. 16. Kido et al., 1982, p. 5, fig. 8. Wakita and Okamura, 1982, Pl. 8, fig. 4.

Remarks. This species differs from *Stichocapsa japonica* Yao in having larger circular pores. Most specimens have four chambers only, where a fifth chamber is present it is either the same size as the fourth chamber or smaller (as in the illustrated specimen).

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80693 from GSC locality C-080594. Additional specimens collected at GSC localities C-080588, C-080589, C-080592, C-080593, and C-080595.

Genus *Tricolocapsa* Haeckel, 1881

Type species. Tricolocapsa theophrasti Haeckel, 1881.

Tricolocapsa (?) *fusiformis* Yao

Tricolocapsa (?) *fusiformis* Yao, 1979, p. 33, Pl. 4, figs. 12-18; Pl. 5, figs. 1-4.

Remarks. Tricolocapsa (?) *fusiformis* is common to the *Hsuum* B and *Unuma echinatus* assemblages (Upper Lower to Middle Middle Jurassic) of Japan (Yao, 1983, p. 369).

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Specimen GSC 80697 (not illustrated). Rare at GSC locality C-080594. Inuyama area, Japan: see Yao (1979).

Tricolocapsa sp. cf. *T. rusti* Tan

Plate 6, figure 3

cf. *Tricolocapsa rusti* Tan, 1927, p. 50, Pl. 9, fig. 65.

Tricolocapsa sp. cf. *T. rusti* Tan, in Yao, 1979, p. 30, Pl. 3, figs. 8-20.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Phantom Creek and Graham Island formations, Graham Island. Illustrated specimen GSC 80698 from GSC locality C-080579. Additional specimens collected at GSC localities C-080597, C-080586, C-080587, C-080589, C-080590, C-080591, C-080593, C-080594, and C-080595. Inuyama area, Japan: see Yao (1979).

Genus *Turanta* Pessagno and Blome, 1982

Type species. Turanta capsensis Pessagno and Blome, 1982.

Turanta morinae Pessagno and Blome

Plate 14, figure 8

Turanta morinae Pessagno and Blome, 1982, p. 300, Pl. 1, figs. 3, 4, 8, 11, 16.

Range. Zones 3 to 6: late middle Toarcian to Aalenian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80699 from GSC locality C-080583. Other specimens found at GSC localities C-080581, C-080582, C-080585, C-080586, and C-080597. Snowshoe Formation of east-central Oregon: see Pessagno and Blome (1982).

Turanta nodosa Pessagno and Blome

Plate 14, figures 3, 11

Turanta nodosa Pessagno and Blome, 1982, p. 301, Pl. 2, fig. 4; Pl. 3, figs. 1-3, 8, 11, 12, 14.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. A single specimen GSC 80700 is illustrated from GSC locality C-080583. Snowshoe Formation of east-central Oregon: see Pessagno and Blome (1982).

Turanta sp. A

Plate 14, figure 7

Turanta sp. A, Pessagno and Blome, 1982, p. 302, Pl. 2, fig. 1.

Range. Zone 4: late middle/early late Toarcian.

Occurrence. Phantom Creek Formation, Graham Island. Illustrated specimen GSC 80701 from GSC locality C-080583. A few additional specimens collected at GSC localities C-080582 and C-080584

Genus A, undet.

Plate 15, figures 11, 13

Remarks. This distinctive form is ovate, with a short stubbv horn and a prominent depression in the cephalo-thoracic area. It appears to have some affinity with *Sethocyrtis multicristata* Rüst (1898, p. 45, Pl. 16, fig. 5) but Rüst's figure does not clearly illustrate the circular area below the horn. Further description must await study of the internal structure. Abundant.

Range. Zones 2 to 7: middle Toarcian to early Bajocian.

Occurrence. Whiteaves Formation, Maude Island; Graham Island Formation, Graham Island. Illustrated specimen GSC 80704 from GSC locality C-080586. Additional specimens collected at GSC localities C-080579, C-080589, C-080591, C-080593, C-080594, and C-080595.

Group ACRITARCHA Evitt

Subgroup HERKOMORPHITAE Downie, Evitt, and Sarjeant

Genus *Lophodictyotidium* Pocock, 1972

Organism B, Sarjeant, 1960, p. 404, Pl. 14, fig. 21.

Lophodictyotidium sp. cf. *L. sarjeanti*

Plate 15, figure 10

cf. *Lophodictyotidium sarjeanti* Pocock, 1972, p. 109 (14), Pl. 25, figs. 5, 6.

Remarks. Lophodictyotidium was identified by Dr. G.E. Rouse (pers. comm., 1984) as an acritarch similar to cysts of the Prasinophycea (chlorophyte algae). It compares closely to *L. sarjeanti*, but may have an inner layer and is approximately twice as large. Maximum diameter measured on 25 specimens, 82.0 (108.0) 130.0 µm. Diameter of *L. sarjeanti*, 52.0 (54.0) 58.0 µm. Colour, amber to reddish brown to black. Pocock restricts *L. sarjeanti* to his Middle Jurassic Floral Zone $J2^2$ (late Bajocian).

Range. Zone 7: early Bajocian.

Occurrence. Graham Island Formation, Graham Island. Illustrated specimen GSC 80705 from GSC locality C-080590. Additional specimens occur at GSC localities C-080587, C-080588, C-080591 and C-080592, *L. sarjeanti* occurs in the Shaunavon Formation, southern Saskatchewan, and the Sawtooth Formation, southern Alberta.

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APPENDIX 1

Descriptions of samples and localities

GSC locality C-080577

Location. Lat. 53°11.82'N, Long. 132°3.63'W.
Formation. Fannin.
Locality information. Creek locality, Maude Island; creek flows onto beach approximately 100 m west of Fannin Bay (southwest coast of Maude Island) about midway through the type section of the Maude Formation (Fig. 2C).
Lithology of sample. Medium grey sandy limestone (fine calcarenite).
Lithology of sequence/sample position. Interbedded medium grey sandstone, dark grey siltstone and rare shale. Collected 54.3 m stratigraphically below top of Fannin Formation. See Figure 3; stratigraphic section 4 of Cameron and Tipper (1985).
Related fossil occurrences. No ammonites; shale microfossil samples barren (B.E.B. Cameron, pers. comm., 1983).
Age. Late Pliensbachian; based on lithology and position in section (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Rich, extremely diverse, well preserved.
Sample collector. B.E.B. Cameron, 1980.
Comments. Locality lithologically similar to sandy limestones exposed on beach just east of Fannin Bay that contain an abundant *"Tiltoniceras" propinquum* fauna.

GSC locality C-080578

Location. Lat. 53°11.82'N, Long. 132°3.63'W.
Formation. Fannin.
Locality information. See C-080577, above.
Lithology of sample. Medium grey sandy limestone (fine calcarenite).
Lithology of sequence/sample position. See C-080577 for sequence information. Collected 60.3 m stratigraphically below top of Fannin Formation.
Related fossil occurrences. See C-080577.
Age. See C-080577.
Radiolarian fauna. Sparse, totally recrystallized; only gross morphology discernible. Many unrecognizable spherical forms.
Sample collector. B.E.B. Cameron, 1980.

GSC locality C-080579

Location. Lat. 53°11.94'N, Long. 132°3.25'W.
Formation. Whiteaves.
Locality information. Creek locality, Maude Island; creek flows onto beach just east of Fannin Bay, above a prominent sandstone with nodular coquinoid beds containing ammonites, bivalves, brachiopods and nautiloids (Fig. 2C).
Lithology of sample. Very dark grey limestone (calcilutite) nodule.
Lithology of sequence/sample position. Pale grey, green weathering shale with limestone nodules and septarian nodules. Collected 20.5 m stratigraphically below top of Whiteaves Formation, see Figure 3; stratigraphic section 6 of Cameron and Tipper (1985).
Related fossil occurrences. One poorly preserved specimen of *Phymatoceras* sp., *Trigonia* spp.
Age. Middle Toarcian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Pyritized, preserved in excellent detail; distinctive and very abundant.
Sample collector. B.E.B. Cameron, 1979.

GSC locality C-080581

Location. Lat. 53°25.01'N, Long. 132°16.16'W.
Formation. Phantom Creek.
Locality information. Yakoun River, Graham Island, 3 km south of Ghost Creek, west side of river (Fig. 2B).
Lithology of sample. Light grey sandy limestone (fine calcarenite).
Lithology of sequence/sample position. Exposed is contact between underlying grey-green weathering shale with nodular and concretionary limestones and septarian nodules and overlying grey-green sandstone. Collected in sandstone 2 m above contact, see Figure 3; stratigraphic section 11 of Cameron and Tipper (1985).
Related fossil occurrences. Ammonites (in limy concretions), nautiloids, belemnites and bivalves.
Age. Middle Toarcian (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Not overly abundant but diverse, well preserved; green in colour.
Sample collector. B.E.B. Cameron, 1982.

GSC localities C-080582, C-080583, and C-080584

Location. Lat. 53°25.19'N, Long. 132°15.64'W.
Formation. Phantom Creek.
Locality information. Yakoun River, Graham Island, approximately 2 km south of Ghost Creek; east side of river (Fig. 2B).
Lithology of sample. Light grey to brownish-grey sandy limestone (fine to very fine calcarenite).
Lithology of sequence/sample position. Grey-green weathering shale overlain by pale brown sandstone with minor shale interbeds and common buff weathering sandy limestone lenses. Collected above high water mark 4.5 m, 10.5 m and 14.5 m stratigraphically above Whiteaves Shale. See Figure 3; stratigraphic section 12 of Cameron and Tipper (1985).
Related fossil occurrence. Ammonites, belemnites.
Age. Late middle or early late Toarcian (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Abundant (particularly hagiastrids), preservation fair to excellent.
Sample collector. B.E.B. Cameron, 1980.

GSC locality C-080585

Location. Lat. 53°25.19'N, Long. 132°15.64'W.
Formation. Phantom Creek.
Locality information. Yakoun River, Graham Island, approximately 2 km south of Ghost Creek; east side of river (Fig. 2B).
Lithology of sample. Light grey limestone (fine grained calcarenite).
Lithology of sequence/sample position. Sequence as in C-080582, C-080583 and C-080584; position also approximately equivalent.
Related fossil occurrences. Ammonites.
Age. Late middle or early late Toarcian (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Abundant, preservation fair to good; most specimens recrystallized.
Sample collector. H.W. Tipper, 1975.
Comments. Very little Jurassic outcrop exposed on river in 1975. Since then floods have made excellent exposures available.

GSC locality C-080597

Location. Lat. 53°25.22'N, Long. 132°15.73'W.
Formation. Phantom Creek.
Locality information. Yakoun River, Graham Island, 1.8 km south of Ghost Creek, east side of river (Fig. 2B).
Lithology of sample. Light grey limestone (fine calcarenite).
Lithology of sequence/sample position. Sequence as in C-080582 to C-080585, collected in sandstone.
Related fossil occurrences. Ammonites.
Age. Late Toarcian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Exceptionally rich, excellent preservation; white and green in colour.
Sample collector. H.W. Tipper, 1975.

GSC locality C-080580

Location. Lat. 53°21.89'N, Long. 132°16.04'W.
Formation. Fannin.
Locality information. Rennell Junction, Graham Island, creek bed above a high waterfall east of McMillan Bloedel's logging road 'Queen Charlotte Main', 0.25 km north of junction of 'Queen Charlotte Main' with road to Rennell Sound (Fig. 2B).
Lithology of sample. Medium grey limestone (fine calcarenite).
Lithology of sequence/sample position. Mostly dark shale and siltstone (lower to upper Pliensbachian) exposed by waterfall. In creek above, sandstone grades upward into grey-green weathering shale with septarian nodules. Collected from highest limestone bed in the sandstones. See Figure 3; stratigraphic section 10 of Cameron and Tipper (1985).
Related fossil occurrences. None.
Age. Late Pliensbachian; based on lithology (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Very sparse; poor preservation.
Sample collector. B.E.B. Cameron, 1980.

GSC locality C-080587

Location. Lat. 53°21.89'N, Long. 132°15.77'W.
Formation. Graham Island.
Locality information. Rennell Junction, Graham Island, see C-080580 for location.
Lithology of sample. Brownish grey sandy limestone (fine calcarenite).
Lithology of sequence/sample position. Condensed Upper Toarcian sandstone overlain by interbedded buff coloured tuffaceous sandstone, siltstone and shale with minor sandy limestone. Collected in siltstone, 182 m upstream of C-080580, 47 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 10 of Cameron and Tipper (1985).
Related fossil occurrences. None.
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Few, well preserved; pale green in colour.
Sample collector. B.E.B. Cameron, 1982.

GSC locality C-080588

Location. Lat. 53°21.89'N, Long. 132°15.73'W.
Formation. Graham Island.
Locality information. Rennell Junction, Graham Island. See C-080580 for location.
Lithology of sample. Buff coloured sandy limestone (fine grained calcarenite).
Lithology of sequence/sample position. Sequence as in C-080587. Collected in light grey pelletal siltstone, 52 m upstream of C-080587; 62.5 m stratigraphically above base of Graham Island Formation.
Related fossil occurrences. None.
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Common, well preserved.
Sample collector. B.E.B. Cameron, 1982.

GSC locality C-080586

Location. Lat. 53°23.19'N, Long. 132°16.23'W.
Formation. Phantom Creek.
Locality information. Small waterfall on east side of Branch Road 59, 0.5 km from 'Queen Charlotte Main'; about 0.75 km north of junction with road to Rennell Sound, (Fig. 2B).
Lithology of sample. Medium dark grey sandy pelletal limestone (fine grained calcarenite).
Lithology of sequence/sample position. Exposed is upper part of Phantom Creek Formation and base of Graham Island Formation. Lowest beds are grey-green weathering shale and siltstone equivalent to shales on Maude Island, Yakoun River and above waterfall at Rennell Junction. Overlying shale is irregularly bedded, poorly sorted sandstone. Above sand, thick sequence of interbedded shale and tuff (Graham Island Formation); collected in sandstone talus block. See Figure 3; stratigraphic section 13 of Cameron and Tipper (1985).
Related fossil occurrences. 'Hammatoceratid' ammonites below sample location; *Tmetoceras* sp. above (H.W. Tipper, pers. comm., 1983).
Age. Aalenian.
Radiolarian fauna. Common, excellent preservation; green in colour.
Sample collector. B.E.B. Cameron, 1982.
Comments. Talus sample almost certainly from sandstone, as it bears no resemblance to overlying rocks.

GSC locality C-080589

Location. Lat. 53°23.65'N, Long. 132°16.41'W.
Formation. Graham Island.
Locality information. Branch Road 57, Graham Island. Intersects 'Queen Charlotte Main' approximately 2 km north of its junction with the Rennell Sound Road. Reached by following Branch Road 57 to top of bluff, then descending ravine to creek at base of waterfall (Fig. 2B).
Sample description. Medium grey limestone (calcisiltite).
Lithology of sequence/sample position. Base of section in fault contact with Phantom Creek Formation. Exposed are dark grey shale and siltstone with rare sandy layers and thin beds of buff weathering concretionary limestone. Collected from shale 2 m above base of formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Related fossil occurrences. A few 'sonninid' ammonites in creek bed and on hillside to north.
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Few, mostly recrystallized.
Sample collector. B.E.B. Cameron, 1982.

GSC Localities C-080590 and C-080591

Location. Lat. 53°23.65'N, Long. 132°16.29'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Medium dark, brownish grey limestone (calcisiltite).
Lithology of sequence/sample position. See C-080589 for sequence. Collected in shale 21 m stratigraphically above

base of Graham Island Formation. See Figure 3; stratigraphic section 14, Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1984).
Radiolarian fauna. Sparse; poorly preserved.
Sample collector. B.E.B. Cameron, 1982.

GSC locality C-080592

Location. Lat. 53°23.64'N, Long. 132°16.21'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Brownish grey limestone (fine grained calcarenite) buff weathering, containing some volcanic glass.
Lithology of sequence/sample position. See C-080589 for sequence. Collected in shale 34 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Few; well preserved.
Sample collector. B.E.B. Cameron, 1980.

GSC locality C-080593

Location. Lat. 53°23.63'N, Long. 132°16.1'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Greenish grey limestone (calcilutite).
Lithology of sequence/sample position. See C-080589 for sequence. Collected in shale 57 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Good; well preserved.
Sample collector. B.E.B. Cameron, 1980.

GSC locality C-080594

Location. Lat. 53°23.63'N, Long. 132°16.07'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Brownish grey limestone (very fine calcarenite).
Lithology of sequence/sample position. See C-080589 for sequence. Collected in shale 59.5 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Common, well preserved; yellowish green in colour.
Sample collector. B.E.B. Cameron, 1982.

GSC locality C-080595

Location. Lat. 53°23.63'N, Long. 132°16.07'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Greenish brown limestone (very fine calcarenite).
Lithology of sequence/sample position. See C-080589 for sequence. Collected in shale 63 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Abundant, excellent preservation; green in colour.
Sample collector. B.E.B. Cameron, 1982.

GSC locality C-080596

Location. Lat. 53°23.54'N, Long. 132°16.2'W.
Formation. Graham Island.
Locality information. See C-080589.
Lithology of sample. Greenish grey sandy limestone (fine grained calcarenite).
Lithology of sequence/sample position. See C-080589 for general section. Collected above waterfall from a sandy, silty section near a pale grey ash bed, 192.5 m stratigraphically above base of Graham Island Formation. See Figure 3; stratigraphic section 14 of Cameron and Tipper (1985).
Age. Early Bajocian (H.W. Tipper, pers. comm., 1983).
Radiolarian fauna. Very few, preservation variable; pale green and white. Only four species identified.
Sample collector. B.E.B. Cameron, 1982.

PLATES 1 to 18

PLATE 1

Scanning electron micrographs of Lower Jurassic (upper Pliensbachian) Spumellariina from the Fannin Formation, Maude Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Praeconocaryomma immodica* Pessagno and Poisson (page 31)

GSC 80522, GSC loc. C-080577, late Pliensbachian; scale = 107 μm.

Figure 2. *Praeconocaryomma* sp. aff. *P. media* Pessagno and Poisson (page 32)

GSC 80523, GSC loc. C-080577, late Pliensbachian; scale = 105 μm.

Figures 3, 6. *Praeconocaryomma whiteavesi* n. sp. (page 31)

3, holotype, GSC 80528; 6, paratype, GSC 80529, GSC loc. C-080577, late Pliensbachian; scales = 72 and 73 μm, respectively.

Figure 4. *Tripocyclia* (?) sp. A (page 27)

GSC 80500, GSC loc. C-080577, late Pliensbachian; scale = 102 μm.

Figure 5. *Praeconocaryomma* (?) *fasciata* n. sp. (page 31)

Holotype, GSC 80530, GSC loc. C-080577, late Pliensbachian; scale = 81 μm.

Figures 7, 10. *Orbiculiforma trispinula* n. sp. (page 44)

7, holotype, GSC 80596; 10, paratype, GSC 80597, GSC loc. C-080577, late Pliensbachian; scale = 90 μm.

Figures 8, 11. *Orbiculiforma kwunaensis* n. sp. (page 44)

11, holotype, GSC 80599; 8, (undescribed form referred to in text) GSC 80598, GSC loc. C-080557, late Pliensbachian; scales = 90 and 100 μm, respectively.

Figure 9. *Orbiculiforma* sp. A. (page 45)

GSC 80600, GSC loc. C-080577, late Pliensbachian; scale = 100 μm.

Figure 12. *Stephanastrum* ? *magnum* n. sp. (page 48)

Holotype, GSC 80618, GSC loc. C-080577, late Pliensbachian; scale = 129 μm.

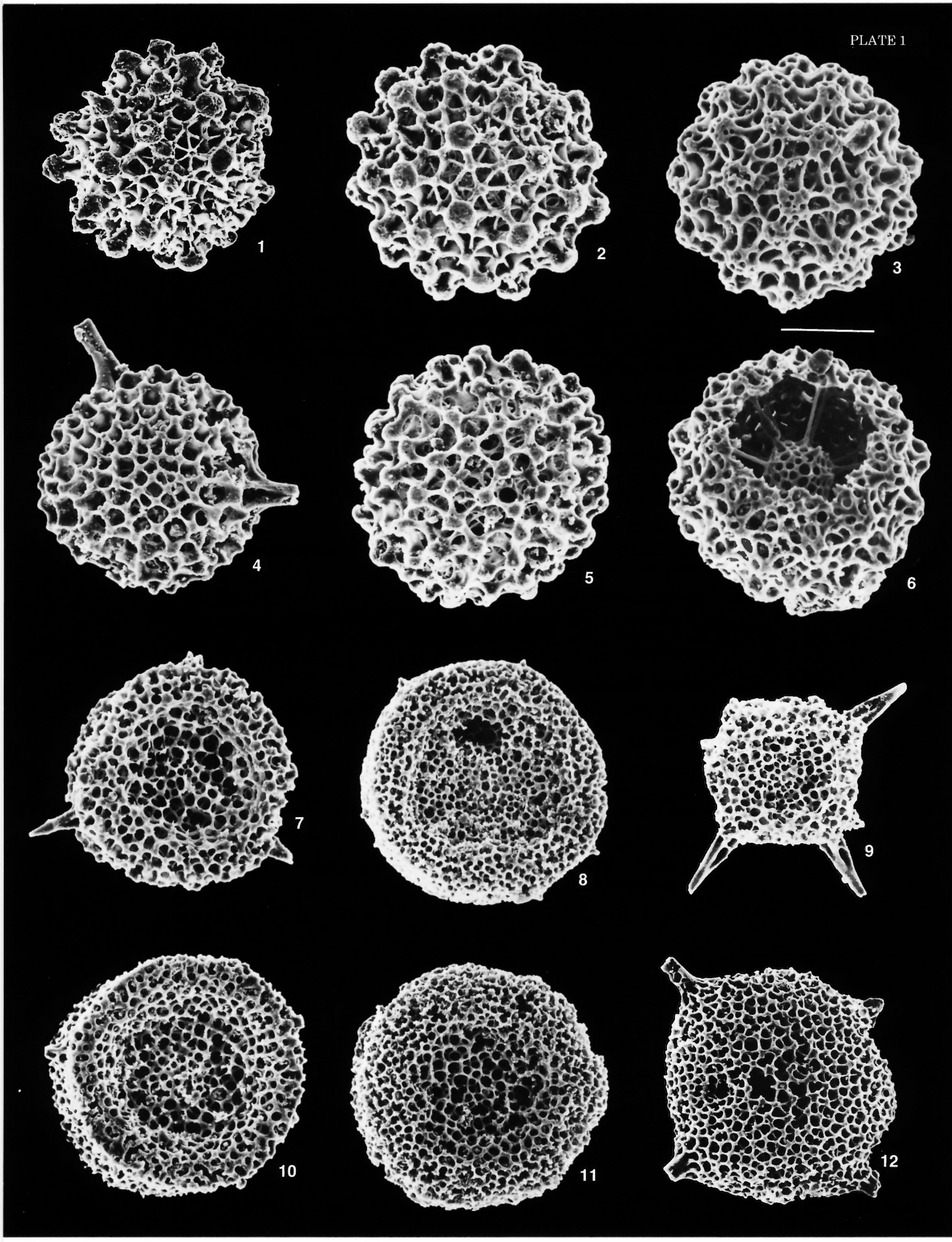
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PLATE 2

Scanning electron micrographs of Lower Jurassic (upper Pliensbachian) Radiolaria from the Fannin Formation, Maude Island, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figure 1. *Pantanellium* sp. cf. *P. haidaense* Pessagno and Blome (page 37)

GSC 80559, GSC loc. C-080557, late Pliensbachian; scale = 83 µm.

Figure 2. *Hagiastrum* sp. A. (page 29)

GSC 80508, GSC loc. C-080577, late Pliensbachian; scale = 111 µm.

Figure 3. *Acaeniotyle* ? sp. A. (page 33)

GSC 80531, GSC loc. C-080577, late Pliensbachian; scale = 100 µm.

Figures 4, 9. *Katroma ninstintsi* n. sp. (page 60)

4, holotype, GSC 80694; 9, paratype, GSC 80695, GSC loc. C-080577, late Pliensbachian; scales = 127 and 118 µm, respectively.

Figures 5, 6. *Drulanta edenshawi* n. sp. (page 53)

5, holotype, GSC 80653; 6, paratype, GSC 80654, GSC loc. C-080577, late Pliensbachian; scales = 124 and 102 µm, respectively.

Figures 7, 8. *Bipedis fannini* n. sp. (page 61)

Holotype, GSC 80702, GSC loc. C-080577, late Pliensbachian; scales = 91 and 78 µm, respectively.

Figures 10, 11. *Poulpus* (?) sp. (page 61)

GSC 80689, GSC loc. C-080577, late Pliensbachian; scales = 91 and 53 µm, respectively.

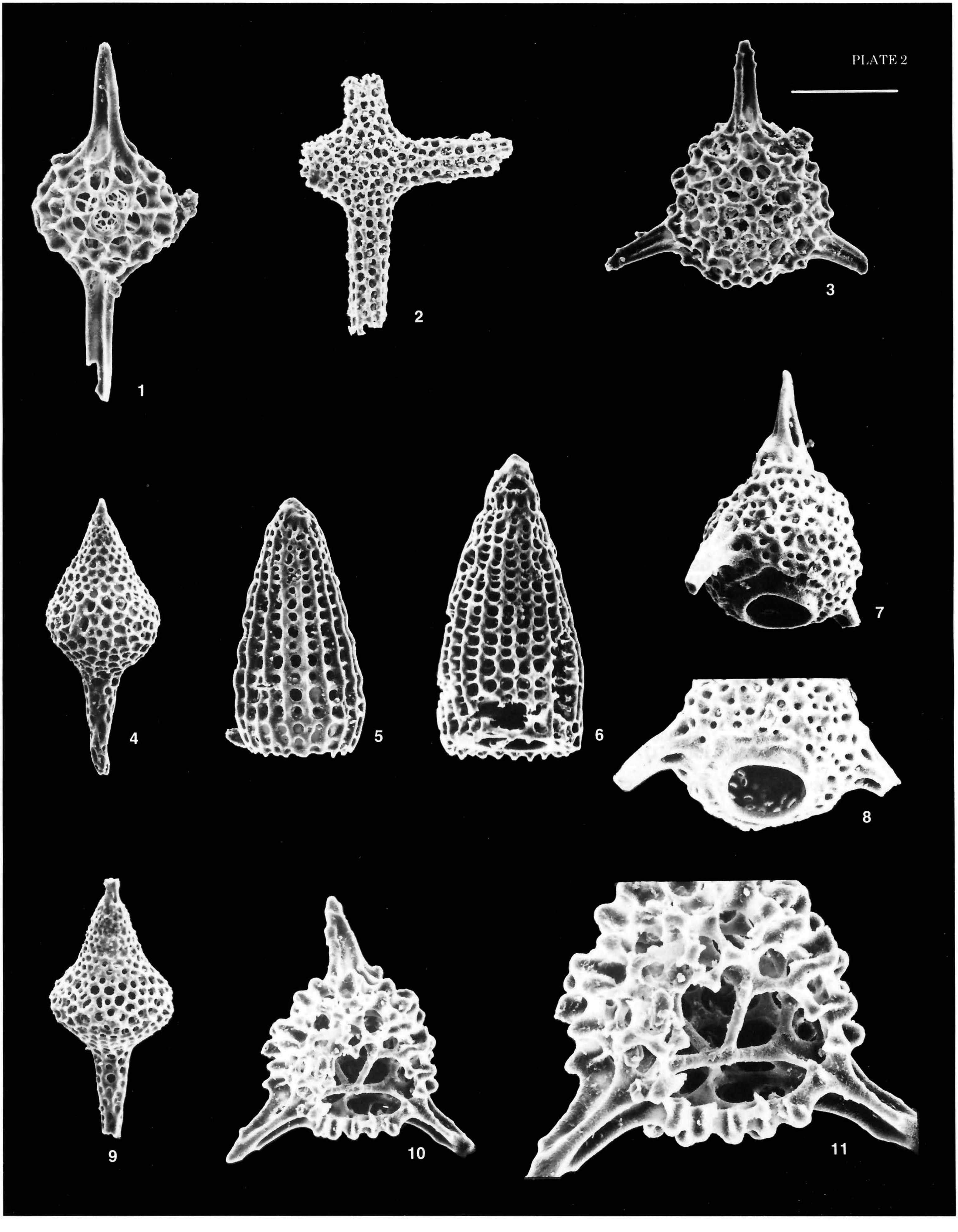
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PLATE 3

Scanning electron micrographs of Lower Jurassic (upper Pliensbachian) Nassellariina from the Fannin Formation, Maude Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Canutus giganteus* Pessagno and Whalen (page 50)

GSC 80636, GSC loc. C-080577, late Pliensbachian; scale = 190 μm.

Figure 2. *Canutus izeensis* Pessagno and Whalen (page 51)

GSC 80638, GSC loc. C-080577, late Pliensbachian; scale = 99 μm.

Figure 3. *Canutus tipperi* Pessagno and Whalen (page 51)

GSC 80639, GSC loc. C-080577, late Pliensbachian; scale = 170 μm.

Figures 4, 9. *Canutus* sp. A (page 51)

GSC 80640, GSC loc. C-080577, late Pliensbachian; scales 172 and 115 μm, respectively.

Figures 5, 8, 12. *Canutus nitidus* Yeh (page 50)

5, GSC 80635, GSC loc. C-80577, late Pliensbachian; scale = 108 μm; 8, 12, GSC 80642, GSC loc. C-080577, late Pliensbachian; scales = 203 μm and 100 μm, respectively.

Figure 6. *Canutus* sp. aff. *C. nitidus* Yeh (page 51)

GSC 80641, GSC loc. C-080577, late Pliensbachian; scale = 177 μm.

Figure 7. *Droltus* sp. cf. *D. lyellensis* Pessagno and Whalen (page 49)

GSC 80624, GSC loc. C-080577, late Pliensbachian; scale = 92 μm.

Figures 10, 11. *Canutus hainaensis* Pessagno and Whalen (page 51)

GSC 80637, GSC loc. C-080577, late Pliensbachian; scales = 96 and 227 μm, respectively.

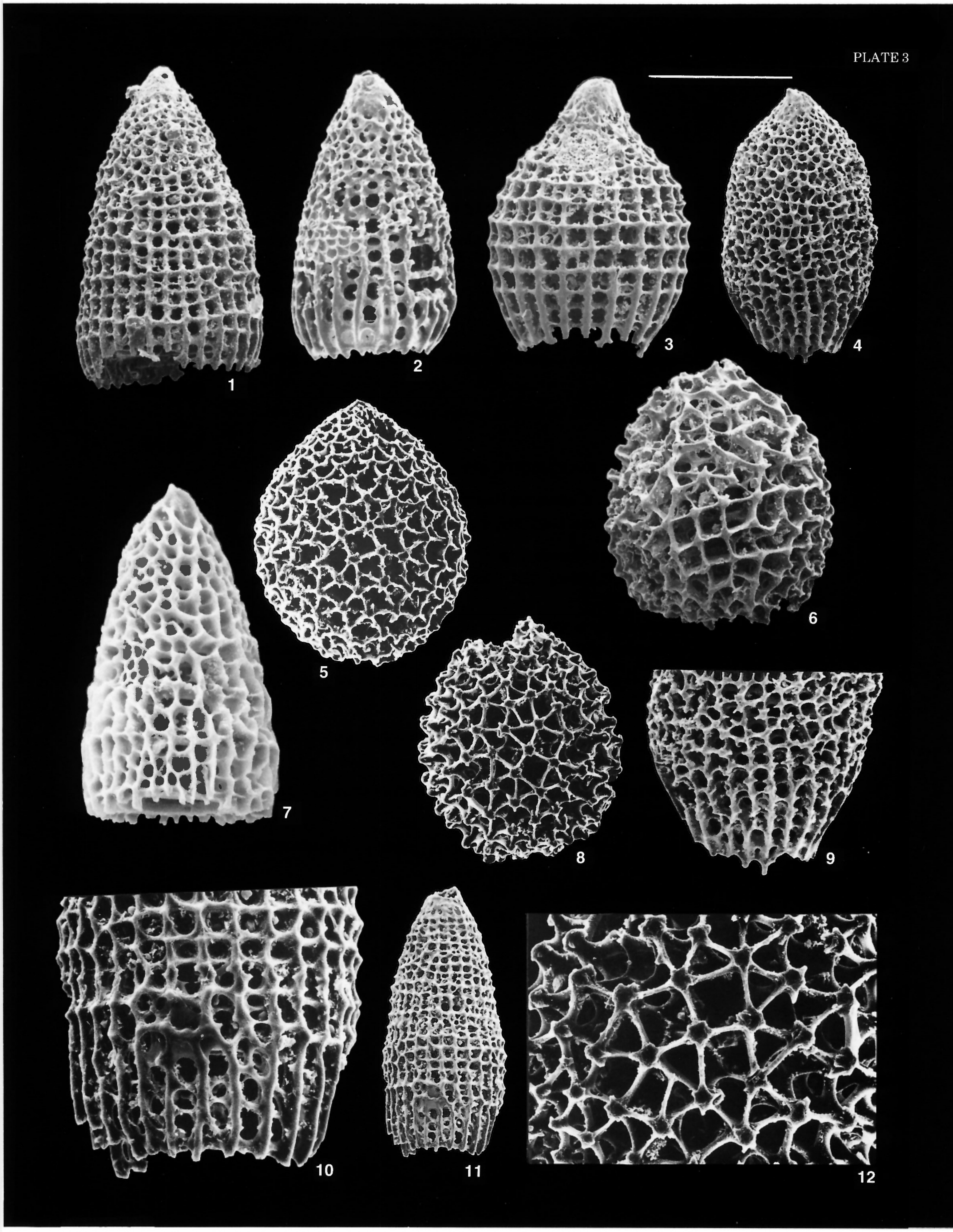
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PLATE 4

Scanning electron micrographs of Lower and Middle Jurassic (upper Pliensbachian - lower Bajocian) Radiolaria from the Fannin, Whiteaves, Phantom Creek and Graham Island formations, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Emiluvia* (?) sp. A (page 36)

GSC 80544, GSC loc. C-080579, middle Toarcian; scale = 61 μm.

Figure 2. *Emiluvia* (?) sp. B (page 36)

GSC 80545, GSC loc. C-080579, middle Toarcian; scale = 100 μm.

Figure 3. *Emiluvia* sp. C (page 36)

GSC 80546, GSC loc. C-080579, middle Toarcian; scale = 100 μm.

Figure 4. *Emiluvia* sp. aff. *E. pessagnoi* Pessagno (page 36)

GSC 80547, GSC loc. C-080595, early Bajocian; scale = 115 μm.

Figure 5. *Emiluvia* (?) *moresbyensis* n. sp. (page 35)

Holotype, GSC 80548, GSC loc. C-080579, middle Toarcian; scale = 119 μm.

Figures 6, 9. *Paronaella porosa* n. sp. (page 40)

6, holotype, GSC 80584, GSC loc. C-080584; 9, paratype, GSC 80585, abberent form with 4 arms. GSC loc. C-080597, late middle/early late Toarcian; scales = 98 and 100 μm, respectively.

Figure 7. *Perispyridium* (?) sp. A (page 59)

GSC 80594, GSC loc. C-080579, middle Toarcian; scale = 57 μm.

Figure 8. *Paronaella* sp. cf. *P. mulleri* Pessagno (page 42)

GSC 80571, GSC loc. C-080579, middle Toarcian; scale = 81 μm.

Figure 10. *Paronaella* sp. A (page 42)

GSC 80574, GSC loc. C-080577, late Pliensbachian; scale = 105 μm.

Figures 11, 12. *Crucella angulosa* n. sp. (page 43)

11, holotype, GSC 80591; 12, paratype, GSC 80592, GSC loc. C-080577, late Pliensbachian; scales = 119 and 150 μm, respectively.

PLATE 4

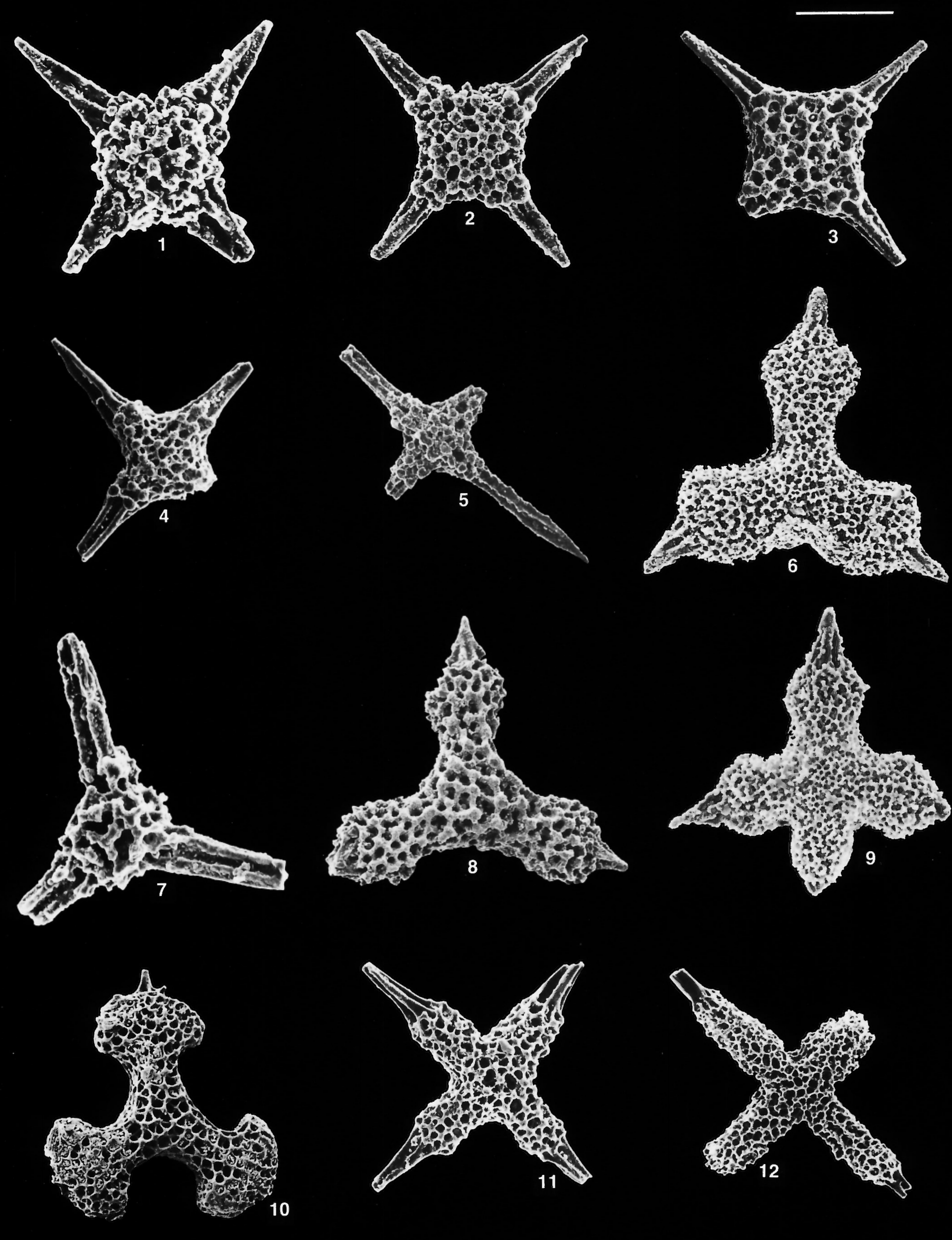

PLATE 5

Scanning electron micrographs of Lower Jurassic (middle to upper Toarcian) Radiolaria from the Whiteaves and Phantom Creek formations, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figure 1. *Parvicingula* (?) sp. A (page 56)

GSC 80661, GSC loc. C-080579, middle Toarcian; scale = 104 µm.

Figure 2. *Hsuum* sp. A (page 52)

GSC 80651, GSC loc. C-080579, middle Toarcian; scale = 167 µm.

Figures 3-5. *Hsuum* sp. cf. *H. rosebudense* Pessagno and Whalen (page 52)

3 (var. A), GSC 80648; 4 (var. B), GSC 80649; 5 (var. C), GSC 80650, GSC loc. C-080579, middle Toarcian; scales = 83, 100, and 82 µm, respectively.

Figure 6. *Hsuum optimus* n. sp. (page 51)

Holotype, GSC 80674, GSC loc. C-080579, middle Toarcian; scale = 128 µm.

Figures 7, 8. *Hsuum* sp. B (page 52)

7, GSC 80672; 8, GSC 80673, GSC loc. C-080597, late Toarcian; scales = 128 and 156 µm, respectively.

Figures 9, 10, 14. *Canoptum anulatum* Pessagno and Poisson (page 50)

10, 14, GSC 80628; 9, GSC 80627 (a large specimen questionably assigned to *C. anulatum*), GSC loc. C-080579, middle Toarcian; scales = 145, 47, and 250 µm, respectively.

Figure 11. *Lupherium* (?) sp. B (page 54)

GSC 80655, GSC loc. C-080579, middle Toarcian; scale = 83 µm.

Figure 12. *Crubus wilsonensis* n. sp. (page 53)

Holotype, GSC 80656, GSC loc. C-080579, middle Toarcian; scale = 152 µm.

Figure 13. *Parvicingula* sp. E (page 56)

GSC 80670, GSC loc. C-080579, middle Toarcian; scale = 115 µm.

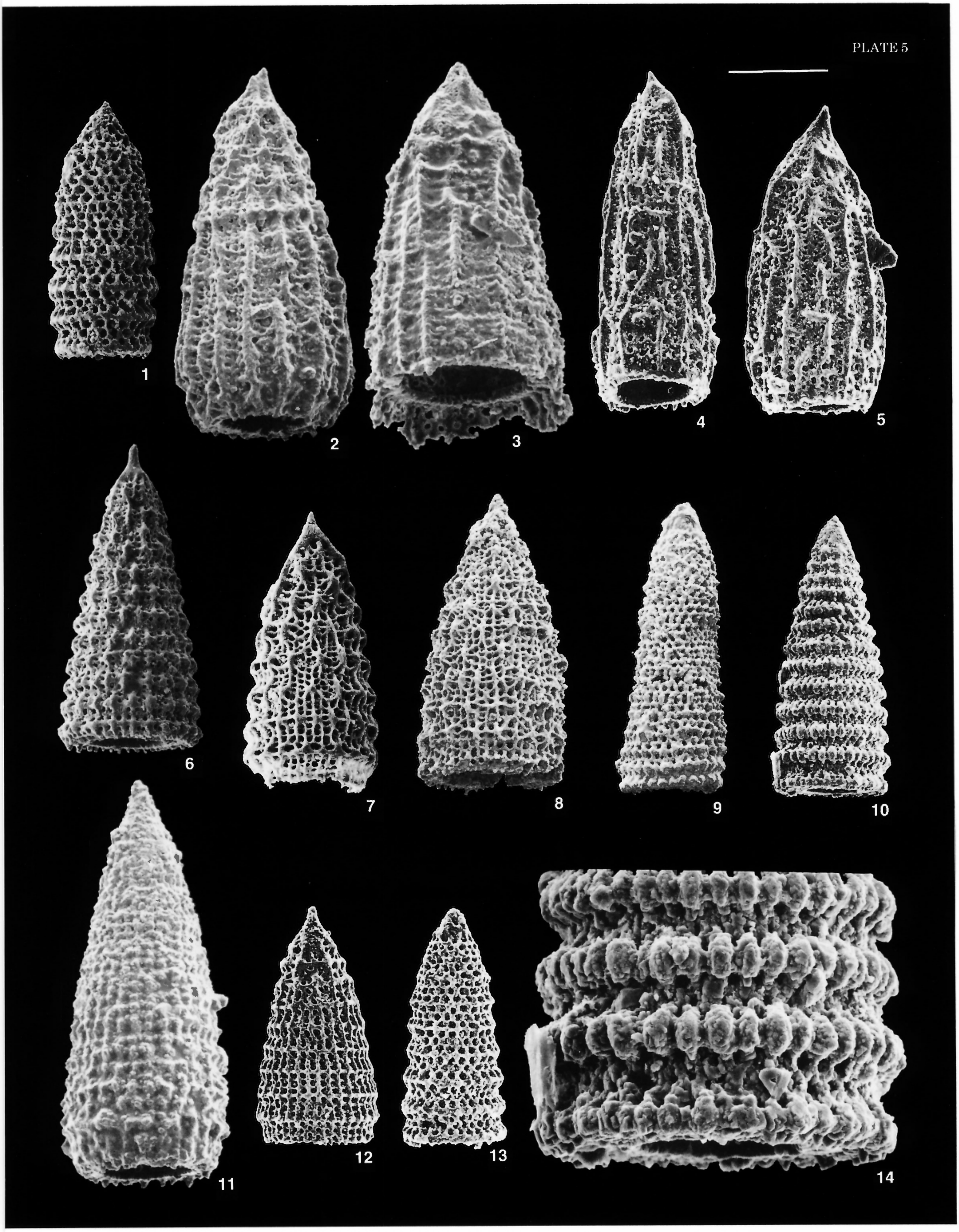
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PLATE 6

Scanning electron micrographs of Lower and Middle Jurassic (upper Pliensbachian to lower Bajocian) Radiolaria from the Fannin, Whiteaves and Graham Island formations, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figures 1, 2. *Protoperispyridium hippaensis* n. sp. (page 59)

1, holotype, GSC 80683, GSC loc. C-080588, early Bajocian; 2, paratype, GSC 80684, GSC loc. C-080579, middle Toarcian; scales 165 and 189 µm, respectively.

Figure 3. *Tricolocapsa* sp. cf. *T. rusti* Tan (page 62)

GSC 80698, GSC loc. C-080579, middle Toarcian; scale = 100 µm.

Figure 4. *Parvicingula boesii* (Parona) group (page 55)

GSC 80687, GSC loc. C-080579, middle Toarcian; scale = 138 µm.

Figures 5, 6. *Stichocapsa* sp. cf. *S. convexa* Yao (page 62)

5, GSC 80691, GSC loc. C-080579, middle Toarcian; scale = 116 µm; 6, GSC 80692, GSC loc. C-080593, early Bajocian; scale = 105 µm.

Figure 7. *Jacus* sp. A (page 58)

GSC 80678, GSC loc. C-080579, middle Toarcian; scale = 230 µm.

Figures 8, 11. *Wrangellium oregonense* Yeh (page 50)

GSC 80630, GSC loc. C-080577, late Pliensbachian; scales = 208 and 83 µm, respectively.

Figures 9, 12. *Protounuma paulsmithi* n. sp. (page 54)

Holotype, GSC 80657, GSC loc. C-080579, middle Toarcian; scales = 173 and 86 µm, respectively.

Figure 10. *Jacus magnificus* n. sp. (page 57)

Holotype, GSC 80676, GSC loc. C-080579, middle Toarcian; scale = 243 µm.

PLATE 6

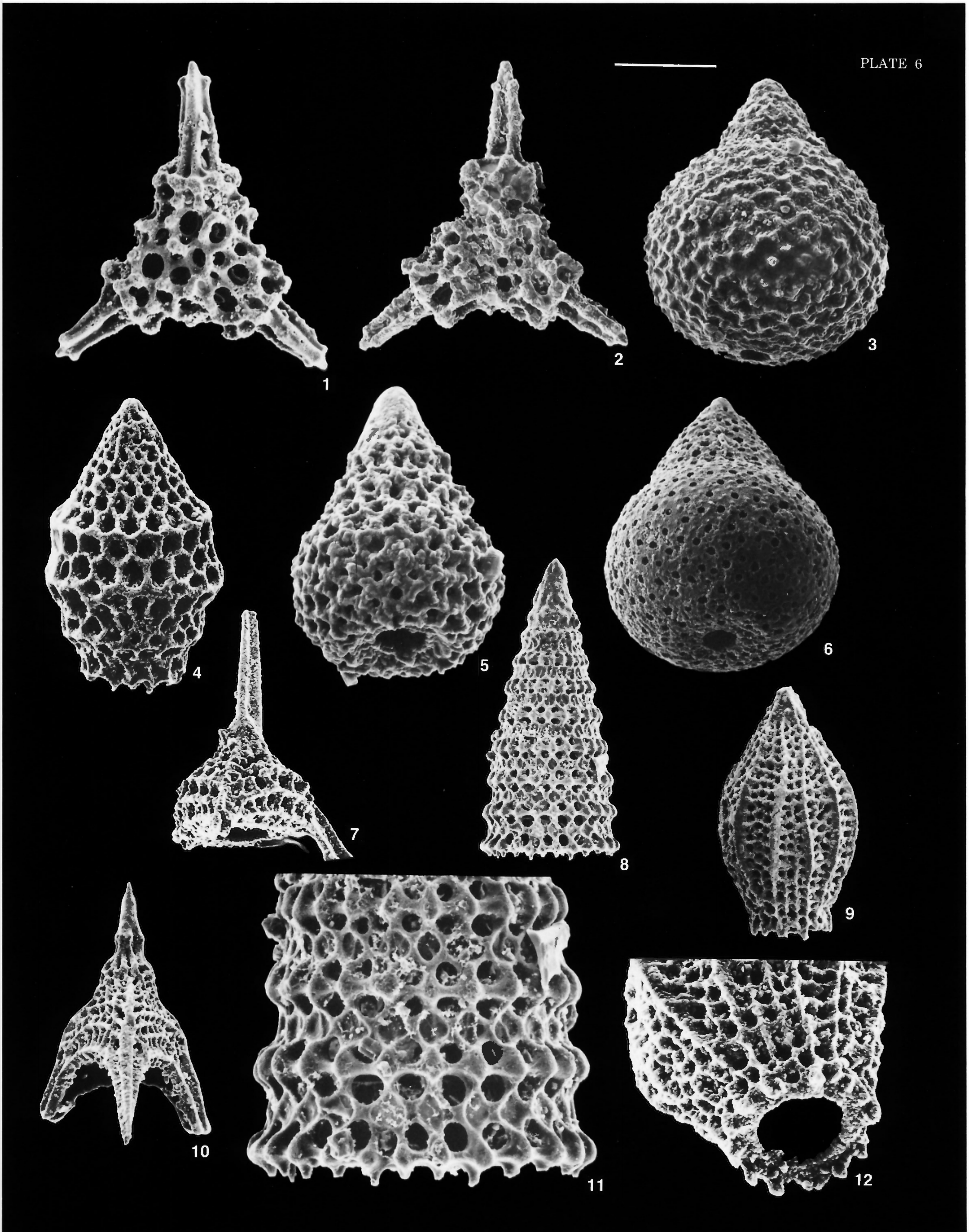

PLATE 7

Scanning electron micrographs of Lower Jurassic (upper middle/lower upper to upper Toarcian) Spumellariina from the Phantom Creek Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1, 4. *Pseudocrucella sanfilippoae* (Pessagno) (page 29)

1, GSC 80511; 4, GSC 80512, GSC loc. C-080597 and C-080583, late middle to late Toarcian; scales = 164 and 192 μm, respectively.

Figures 2, 3. *Homeoparonaella reciproca* n. sp. (page 28)

Holotype, GSC 80505, GSC loc. C-080584, late middle/early Toarcian; scales = 190 and 53 μm, respectively.

Figures 5, 6. *Homeoparonaella* sp. aff. *H. argolidensis* Baumgartner (page 28)

GSC 80503, GSC loc. C-080584, late middle/early late Toarcian; scales = 206 and 50 μm, respectively.

Figure 7. *Pseudocrucella* sp. C (page 30)

GSC 80516, GSC loc. C-080583, late middle/early late Toarcian; scale = 168 μm.

Figures 8, 9. *Pseudocrucella* sp. A (page 29)

GSC 80513, GSC loc. C-080584, late middle/early late Toarcian; scales = 143 and 54 μm, respectively.

Figure 10. *Tetratrabs* sp. aff. *T. gratiosa* Baumgartner (page 30)

GSC 80518, GSC loc. C-080584, late middle/early late Toarcian; scale = 210 μm.

Figures 11, 12. *Hagiastrum* sp. cf. *H. egregium* Rüst (page 29)

11, GSC 80506; 12, GSC 80507, GSC locs. C-080583 and C-080597, late middle/early late to late Toarcian; scales = 311 and 57 μm, respectively.

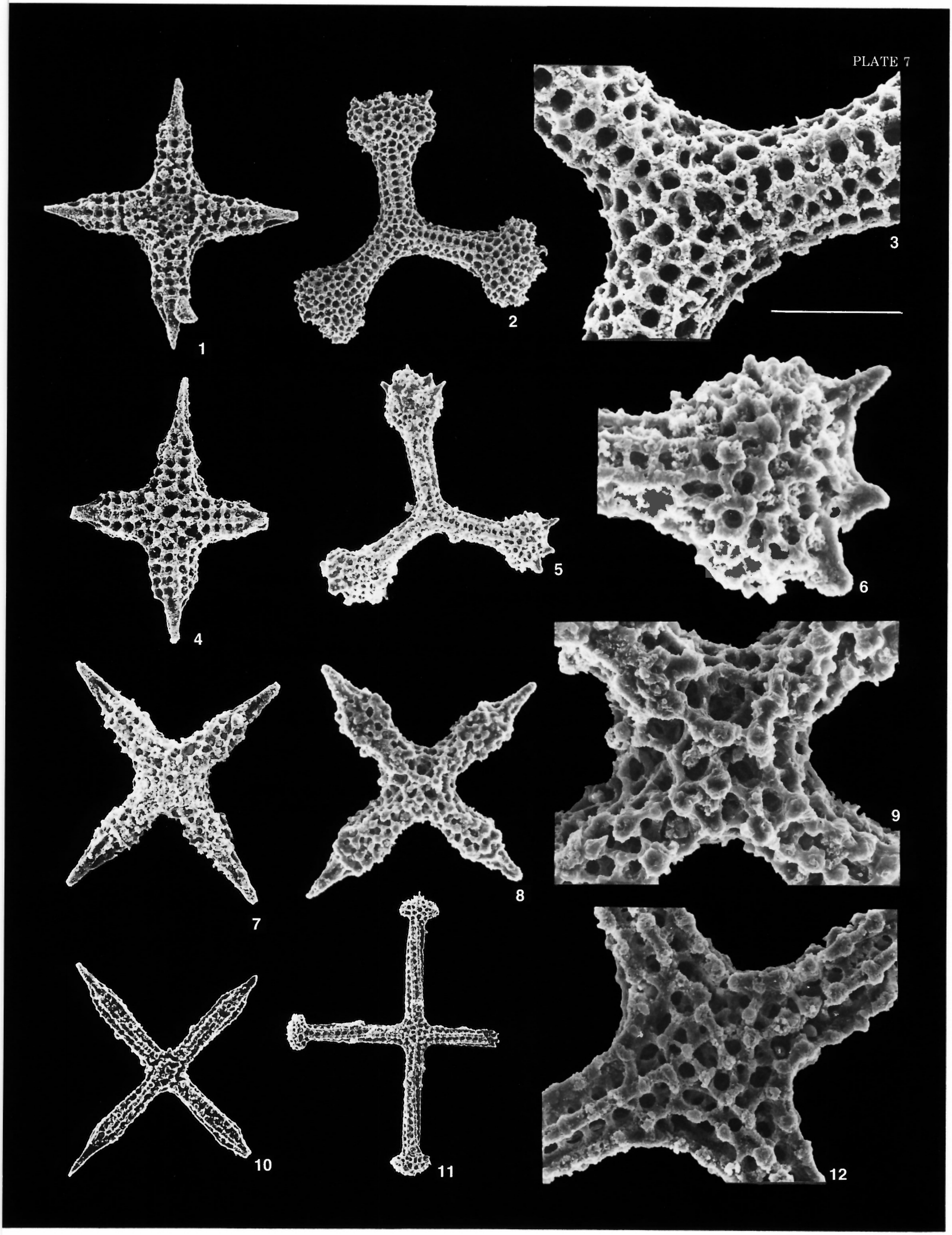
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PLATE 8

Scanning electron micrographs of Lower and Middle Jurassic (upper middle/lower upper Toarcian to Aalenian) Radiolaria from the Phantom Creek Formation, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1, 4. *Staurolonche* (?) sp. A (page 34)

1, GSC 80550; 4, GSC 80551, GSC loc. C-080583, late middle/early late Toarcian; scales = 122 and 100 μm, respectively.

Figures 2, 3. *Emiluvia* sp. D (page 36)

GSC 80535, GSC loc. C-080584, late middle/early late Toarcian; scales = 198 and 68 μm, respectively.

Figures 5, 6. *Staurolonche ellsi* n. sp. (page 33)

Holotype, GSC 80549, GSC loc. C-080597, late Toarcian; scales = 131 and 73 μm, respectively.

Figure 7. *Alievium* ? *juskatlaensis* n. sp. (page 44)

Holotype, GSC 80595, GSC loc. C-080583, late middle/early late Toarcian; scale = 185 μm.

Figures 8, 9. *Staurolonche* (?) sp. B (page 34)

GSC 80552, GSC loc. C-080597, late Toarcian; scales = 140 and 57 μm, respectively.

Figures 10-12. ?*Staurosphaera amplissima* (Foreman) (page 27)

10, GSC 80537, GSC loc. C-080586, Aalenian; 11, 12, GSC 80538, GSC loc. C-080584, late middle/early late Toarcian; scales = 301, 172, and 28 μm, respectively.

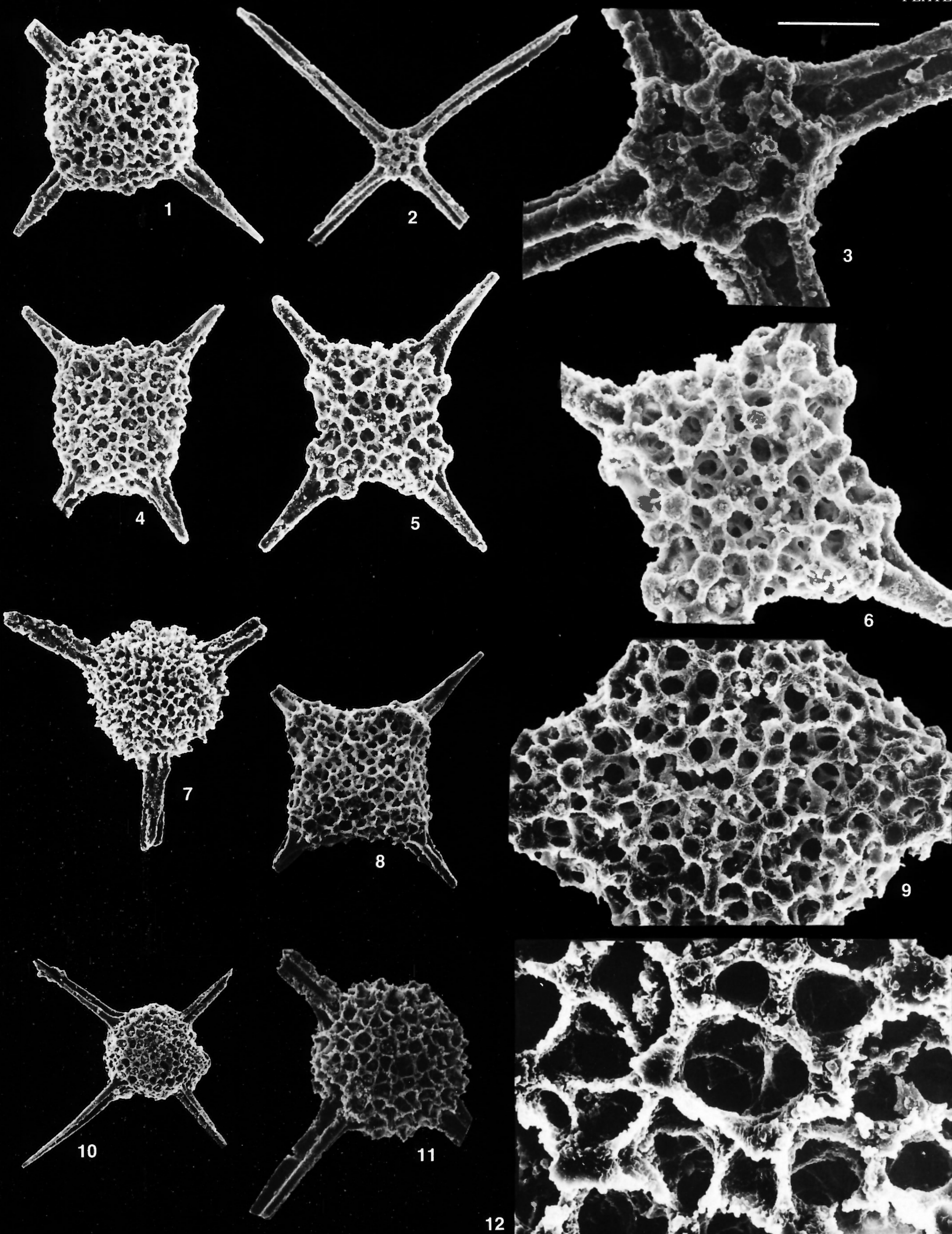
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PLATE 9

Scanning electron micrographs of Lower and Middle Jurassic (upper middle/lower upper Toarcian to Aalenian) Spumellariina from the Phantom Creek Formation, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Praeconocaryomma* sp. aff. *P. parvimamma* Pessagno and Poisson (page 32)

GSC 80524, GSC loc. C-080597, late Toarcian; scale = 49 μm.

Figure 2. *Praeconocaryomma* sp. aff. *P. mamillaria* Pessagno (page 32)

GSC 80525, GSC loc. C-080597, late Toarcian; scale = 48 μm.

Figure 3. *Acaeniotyle* (?) sp. B (page 33)

GSC 80533, GSC loc. C-080597, late Toarcian; scale = 112 μm.

Figures 4, 5. *Tympaneides charlottensis* n. sp. (page 37)

4, holotype, GSC 80555; 5, paratype, GSC 80556, GSC loc. C-080583, late middle/early late Toarcian; scales = 100 and 117 μm, respectively.

Figure 6. *Acaeniotyle* (?) *ghostensis* n. sp. (page 33)

Holotype, GSC 80532, GSC loc. C-080597, late Toarcian; scale = 89 μm.

Figures 7-9. *Caltrop nodosum* n. sp. (page 48)

Holotype, GSC 80619; 7, 9 apical views; 8, lateral view, GSC loc. C-080584, late middle/early late Toarcian; scales = 89, 79, and 50 μm, respectively.

Figure 10. *Mesosaturnalis* sp. cf. *M. septispinus* (Yao) (page 48)

GSC 80617, GSC loc. C-080584, late middle/early late Toarcian; scale = 130 μm.

Figures 11, 12. *Mesosaturnalis hexagonus* (Yao) (page 47)

11, GSC 80615, GSC loc. C-080583, late middle/early late Toarcian; 12, GSC 80616 (enlargement of secondary spine, showing well developed spine ridges), GSC loc. C-080586, Aalenian; scales = 129 and 19 μm, respectively.

PLATE 9

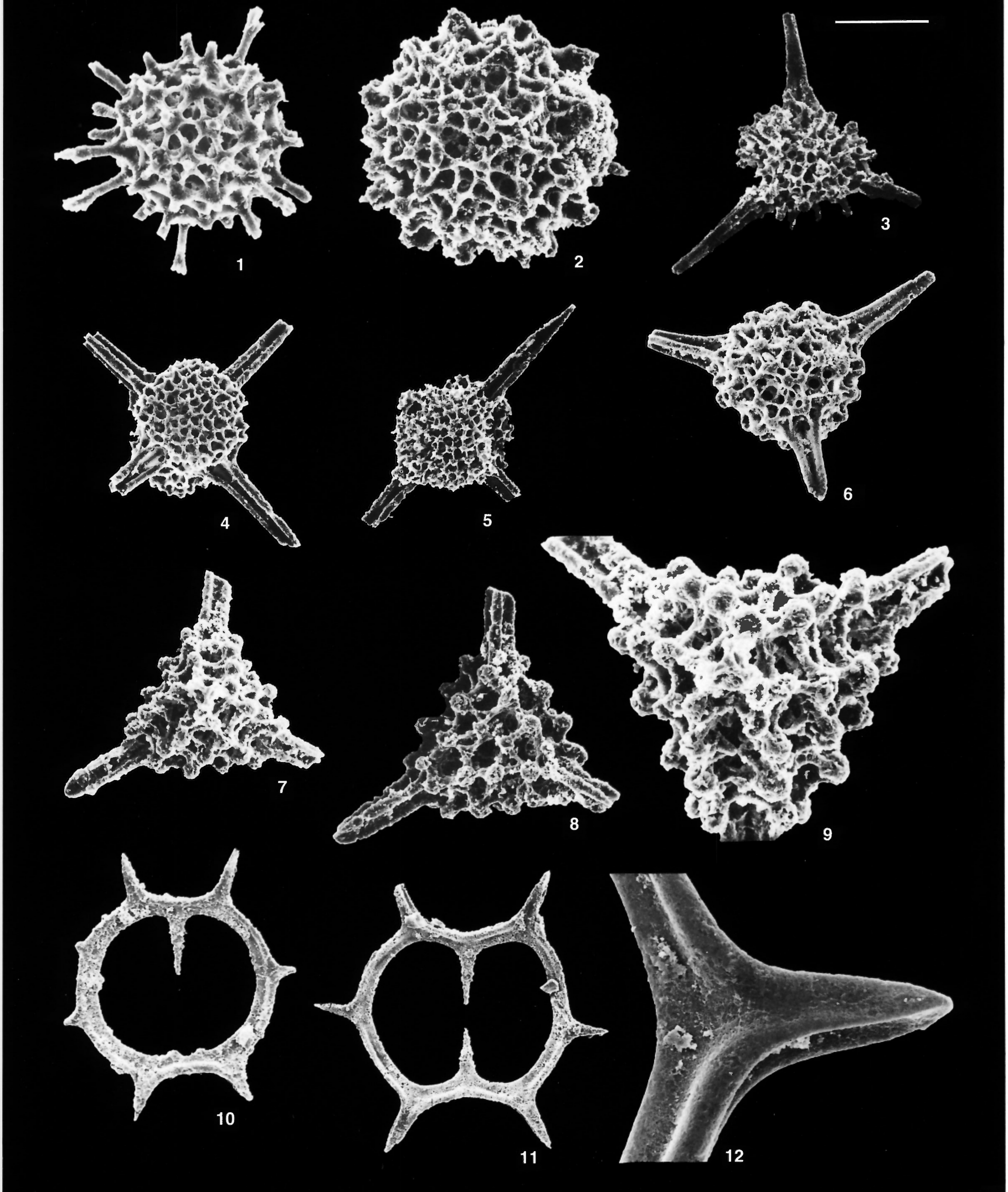

PLATE 10

Scanning electron micrographs of Lower and Middle Jurassic (upper middle/lower upper Toarcian to lower Bajocian) Radiolaria from the Phantom Creek and Graham Island formations, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figure 1. *Tripocyclia rosespitense* n. sp. (page 27)

Holotype, GSC 80502, GSC loc. C-080597, late Toarcian; scale = 126 µm.

Figures 2, 3. *Tripocyclia* sp. B. (page 28)

GSC 80501, GSC loc. C-080597, late Toarcian; scales = 134 and 33 µm, respectively.

Figure 4. Unnamed spongodiscid (page 47)

GSC 80499, GSC loc. C-080583, late middle/early late Toarcian; scale = 124 µm.

Figure 5. *Spongotripus incomptus* n. sp. (page 47)

Holotype, GSC 80614, GSC loc. C-080583, late middle/early late Toarcian; scale = 100 µm.

Figure 6. *Higumastra* sp. A (page 29)

GSC 80510, GSC loc. C-080595, early Bajocian; scale = 141 µm.

Figures 7, 10. *Spongotrochus* (*Stylospongidium*) sp. aff. *S.* (*S.*) *echinodiscus* Clark and Campbell (page 46)

7, GSC 80607; 10, GSC 80608: surface layer broken away to reveal inner concentric spongy structure, GSC loc. C-080597, late Toarcian; scales = 151 and 150 µm, respectively.

Figures 8, 9. *Spongotrochus tanaensis* n. sp. (page 46)

8, holotype, GSC 80609 from GSC loc. C-080597; 9, paratype, GSC 80610 from GSC C-080583, late Toarcian, late middle/early late Toarcian, respectively; scales = 105 and 138 µm, respectively.

Figure 11. *Spongostaurus cruciformis* n. sp. (page 45)

Holotype, GSC 80603, GSC loc. C-080583, late middle/early late Toarcian; scale = 107 µm.

Figure 12. *Spongostaurus* sp. A (page 45)

GSC 80606, GSC loc. C-080597, late Toarcian; scale = 92 µm.

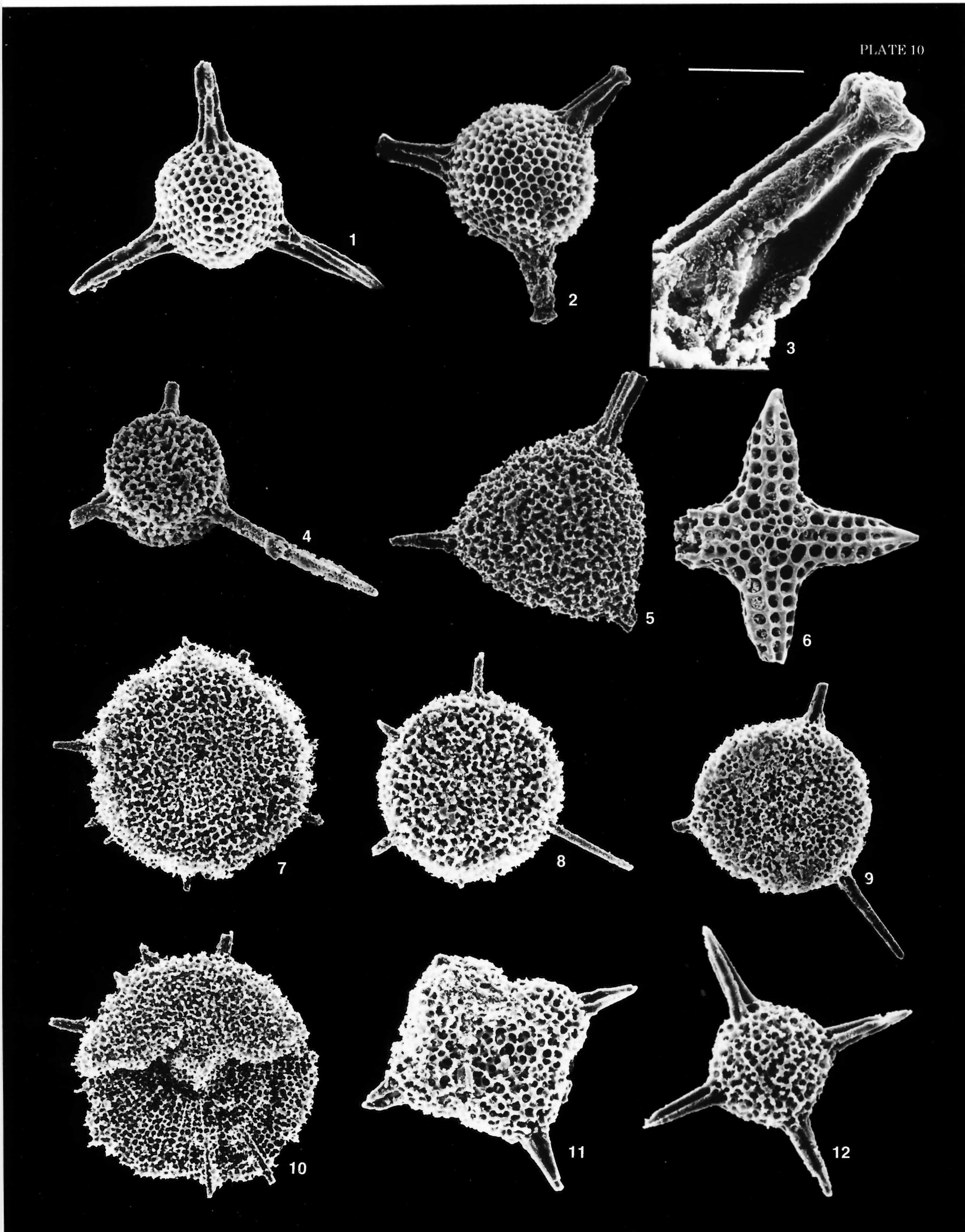
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PLATE 11

Scanning electron micrographs of Lower Jurassic (upper middle/lower upper to upper Toarcian) Patulibracchiidae from the Phantom Creek Formation, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1-3. *Paronaella variabilis* n. sp. (page 41)

1, holotype, GSC 80578, GSC loc. C-080584; 2, 3, paratypes, GSC 80579 and 80580, respectively, GSC loc. C-080583, late middle/early late Toarcian; scales = 127 and 152 μm, respectively.

Figures 4, 5. *Paronaella skowkonaensis* n. sp. (page 40)

4, holotype, GSC 80575, GSC loc. C-080584; 5, paratype, GSC 80576, GSC loc. C-080597, late middle/early late to late Toarcian, respectively; scales = 173 and 171 μm, respectively.

Figure 6. *Paronaella* sp. B (page 42)

GSC 80577, GSC loc. C-080584, late middle/early late Toarcian; scale = 150 μm.

Figure 7. *Paronaella* sp. C (page 42)

GSC 80586, GSC loc. C-080583, late middle/early late Toarcian; scale = 83 μm.

Figure 8. *Paronaella bandyi* ? Pessagno (page 39)

GSC 80568, GSC loc. C-080585, late middle/early late Toarcian; scale = 100 μm.

Figure 9. *Paronaella* sp. D (page 42)

GSC 80587, GSC loc. C-080583, late middle/early late Toarcian; scale = 100 μm.

Figures 10-12. *Paronaella grahamensis* n. sp. (page 40)

11, 12, holotype, GSC 80582; 10, paratype, GSC 80581, GSC loc. C-080583, late middle/early late Toarcian; scales = 135, 46, and 138 μm, respectively.

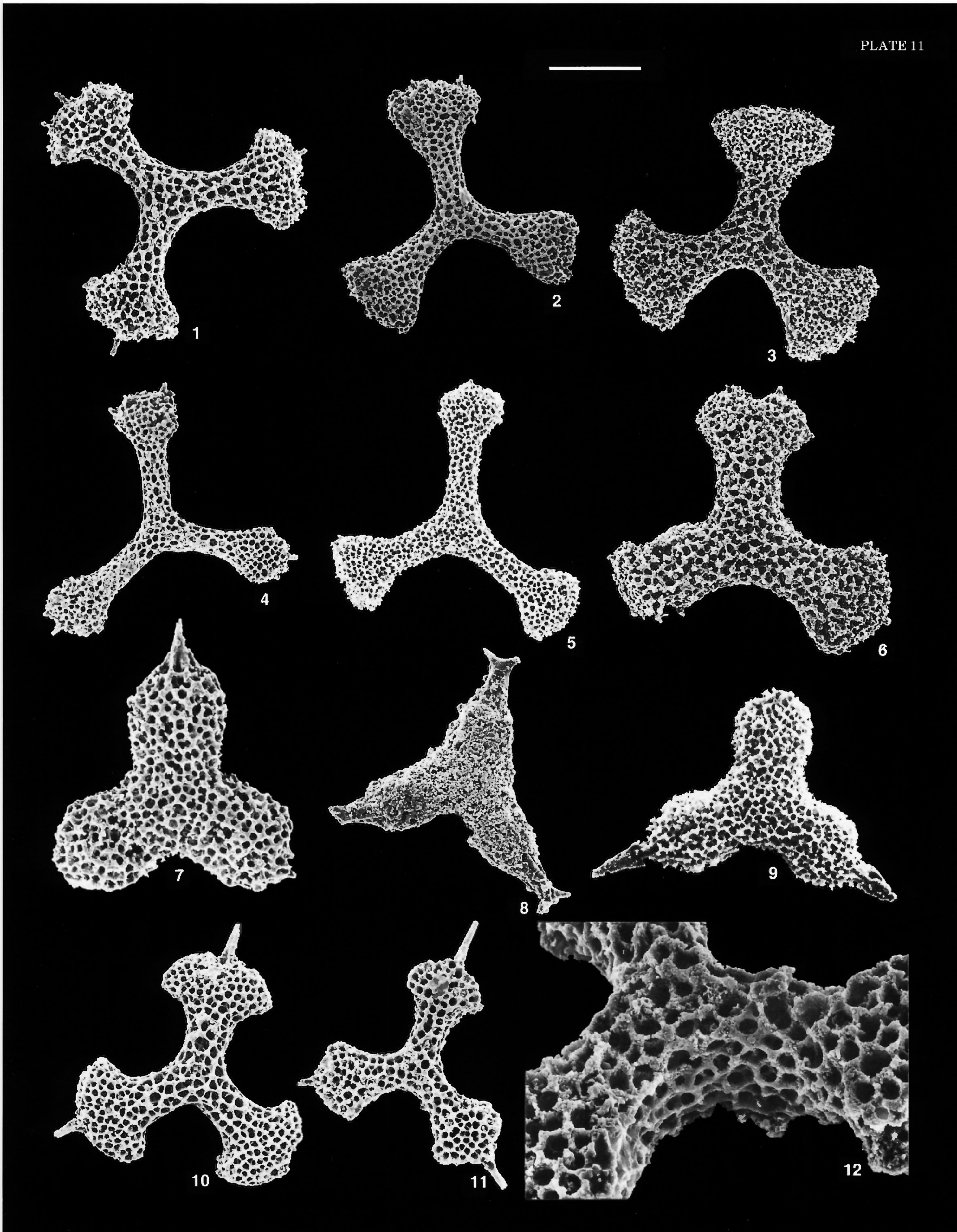
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PLATE 12

Scanning electron micrographs of Lower Jurassic (upper middle/lower upper to upper Toarcian) Spumellariina from the Phantom Creek Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figure 1. *Amphibrachium* (?) *phantomensis* n. sp. (page 39)

Holotype, GSC 80567, GSC loc. C-080597, late Toarcian; scale = 100 µm.

Figures 2, 5. ?*Heliodiscus inchoatus* Rüst (page 38)

GSC 80566, GSC loc. C-080597, late Toarcian; scales = 72 and 83 µm, respectively.

Figure 3. *Paronaella* sp. aff. *P. grahamensis* (page 41)

GSC 80583, GSC loc. C-080597, late Toarcian; scale = 97 µm.

Figures 4, 7, 10. *Spongiostoma saccideon* n. sp. (page 46)

4, 10, holotype, GSC 80611; 7, paratype, GSC 80612, GSC loc. C-080583, late middle/early late Toarcian; scales = 113, 94, and 115 µm, respectively.

Figure 6. *Paronaella* sp. E (page 42)

GSC 80588, GSC loc. C-080585, late middle/early late Toarcian; scale = 153 µm.

Figures 8, 9. *Spongiostoma* sp. A (page 47)

GSC 80613, GSC loc. C-080583, late middle/early late Toarcian; scales = 140 and 89 µm, respectively.

Figures 11, 12. *Crucella* sp. aff. *C. squama* (Kozlova) (page 43)

GSC 80590, GSC loc. C-080583, late middle/early late Toarcian; scales = 80 and 24 µm, respectively.

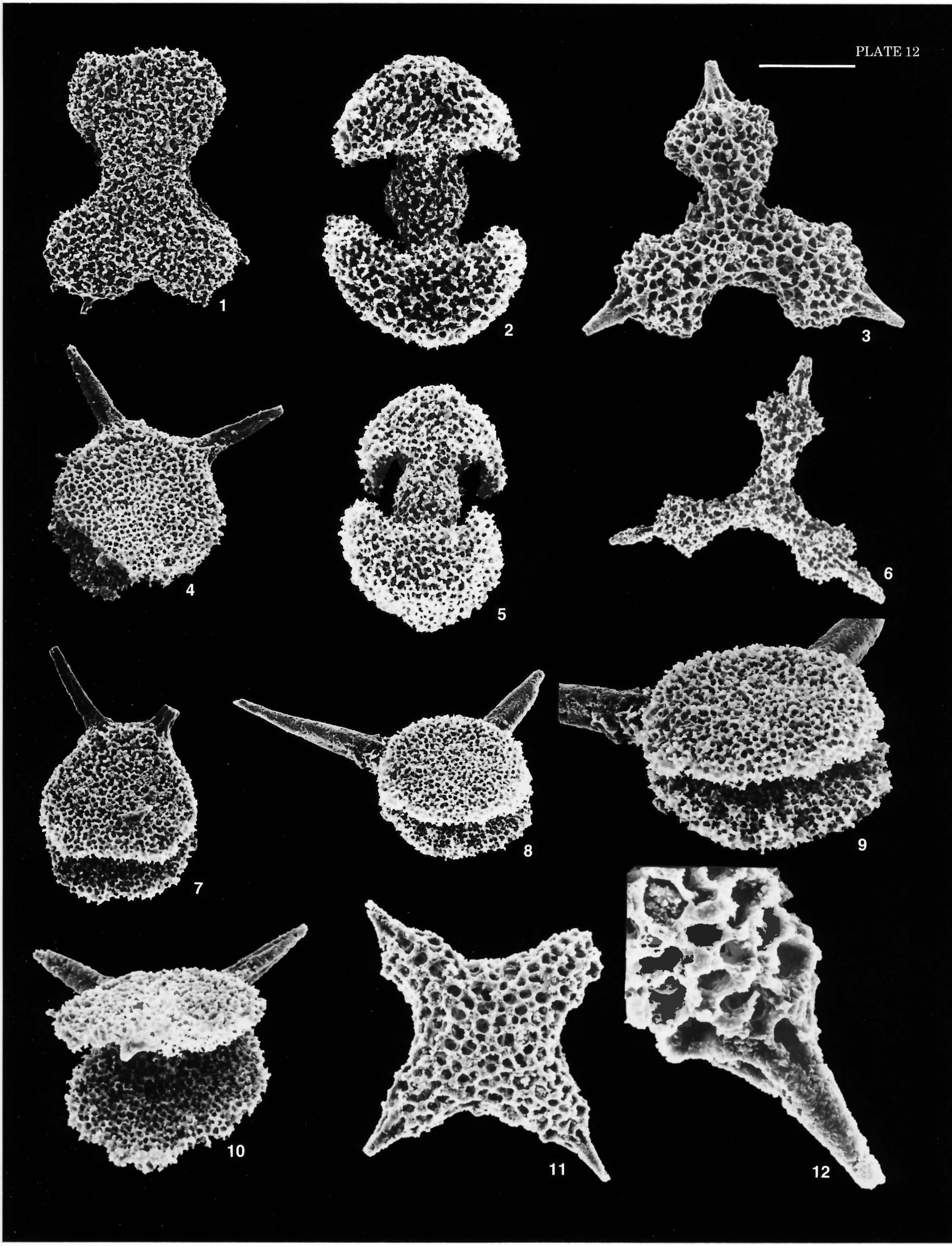
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PLATE 13

Scanning electron micrographs of Lower Jurassic (upper middle to upper Toarcian) Nassellariina from the Phantom Creek Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1, 2, 6, 9. *Elodium cameroni* n. sp. (page 56)

2, 6, 9, holotype, GSC 80631; 1, paratype, GSC 80632, GSC loc. C-080597, late Toarcian; scales = 173, 56, 106, and 153 μm, respectively.

Figures 3, 8, 11. *Elodium nadenensis* n. sp. (page 57)

3, 8, 11, holotype, GSC 80633, GSC loc. C-080581, late middle Toarcian; scales = 143, 37, and 34 μm, respectively.

Figures 4, 7. *Elodium* (?) sp. A (page 57)

4, 7, GSC 80634, GSC loc. C-080581, late middle Toarcian; scales = 140 and 71 μm, respectively.

Figures 5, 10, 12. *Lupherium* (?) sp. B (page 54)

5, 10, 12, GSC 80758, GSC loc. C-080583, late middle/early late Toarcian; scales = 141, 42, and 50 μm, respectively.

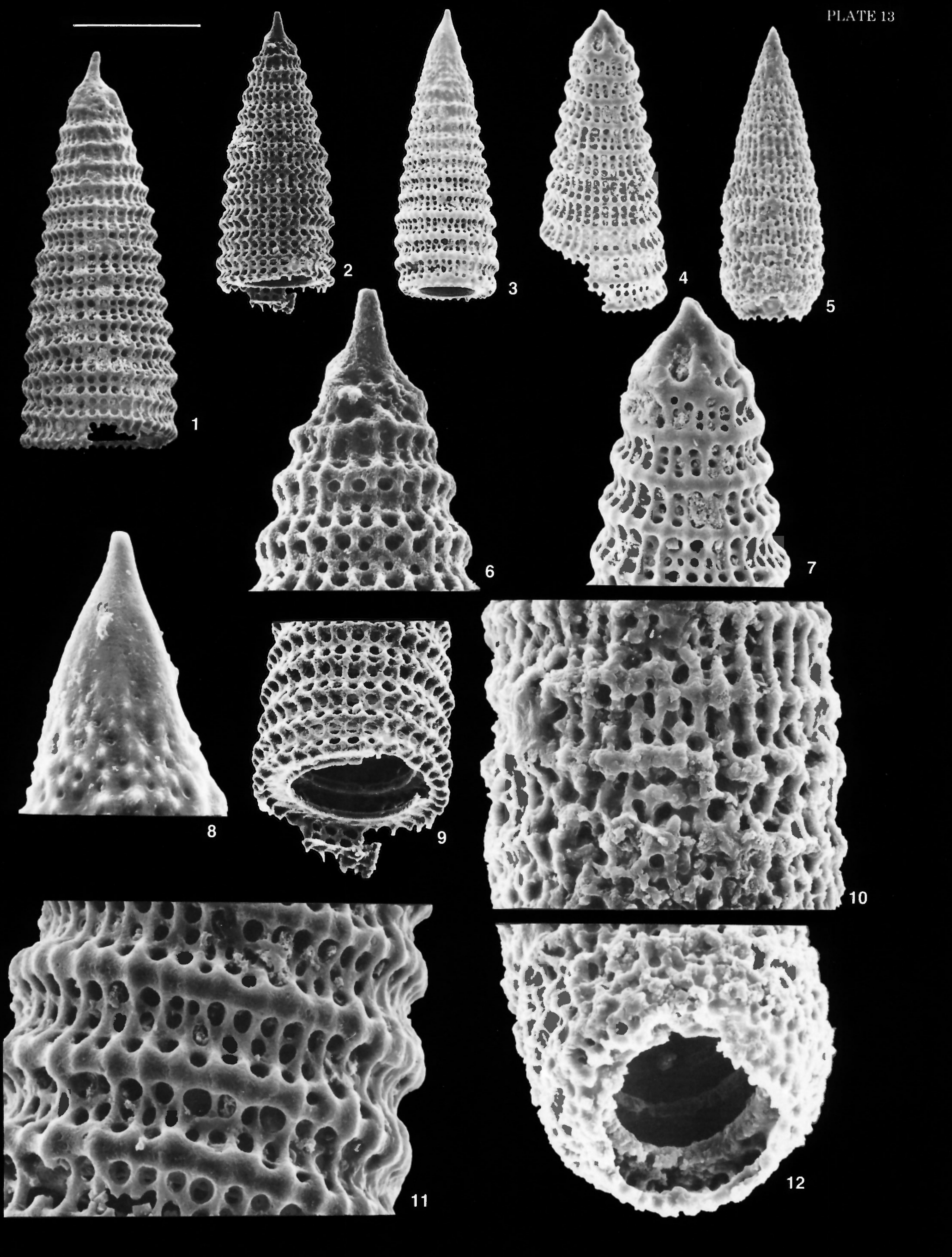

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PLATE 14

Scanning electron micrographs of Lower Jurassic (upper middle/lower upper to upper Toarcian) Nassellariina from the Phantom Creek Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Napora* sp. aff. *N. turgida* Pessagno, Whalen, and Yeh (page 58)

GSC 80677, GSC loc. C-080583, late middle/early late Toarcian; scale = 77 μm.

Figure 2. *Napora* sp. aff. *N. cosmica* Pessagno, Whalen, and Yeh (page 58)

GSC 80679, GSC loc. C-080584, late middle/early late Toarcian; scale = 100 μm.

Figures 3, 11. *Turanta nodosa* Pessagno and Blome (page 63)

GSC 80700, GSC loc. C-080583, late middle/early late Toarcian; scales = 74 and 47 μm, respectively.

Figure 4. *Rolumbus kiustaense* n. sp. (page 58)

Holotype, GSC 80681, GSC loc. C-080583, late middle/early late Toarcian; scale = 111 μm.

Figure 5. *Lithomelissa* sp. A (page 62)

GSC 80703, GSC loc. C-080597, late Toarcian; scale = 89 μm.

Figure 6. *Canoptum* (?) sp. A (page 50)

GSC 80629, GSC loc. C-080597, late Toarcian; scale = 71 μm.

Figure 7. *Turanta* sp. A (page 63)

GSC 80701, GSC loc. C-080583, late middle/early late Toarcian; scale = 103 μm.

Figure 8. *Turanta morinae* Pessagno and Blome (page 62)

GSC 80699, GSC loc. C-080583, late middle/early late Toarcian; scale = 96 μm.

Figure 9. *Maudia yakounense* n. sp. (page 61)

Holotype, GSC 80690, GSC loc. 080585, late middle/early late Toarcian; scale = 183 μm.

Figure 10. *Canoptum* sp. cf. *C. dixoni* Pessagno and Whalen (page 50)

GSC 80626, GSC loc. C-080597, late Toarcian; scale = 133 μm.

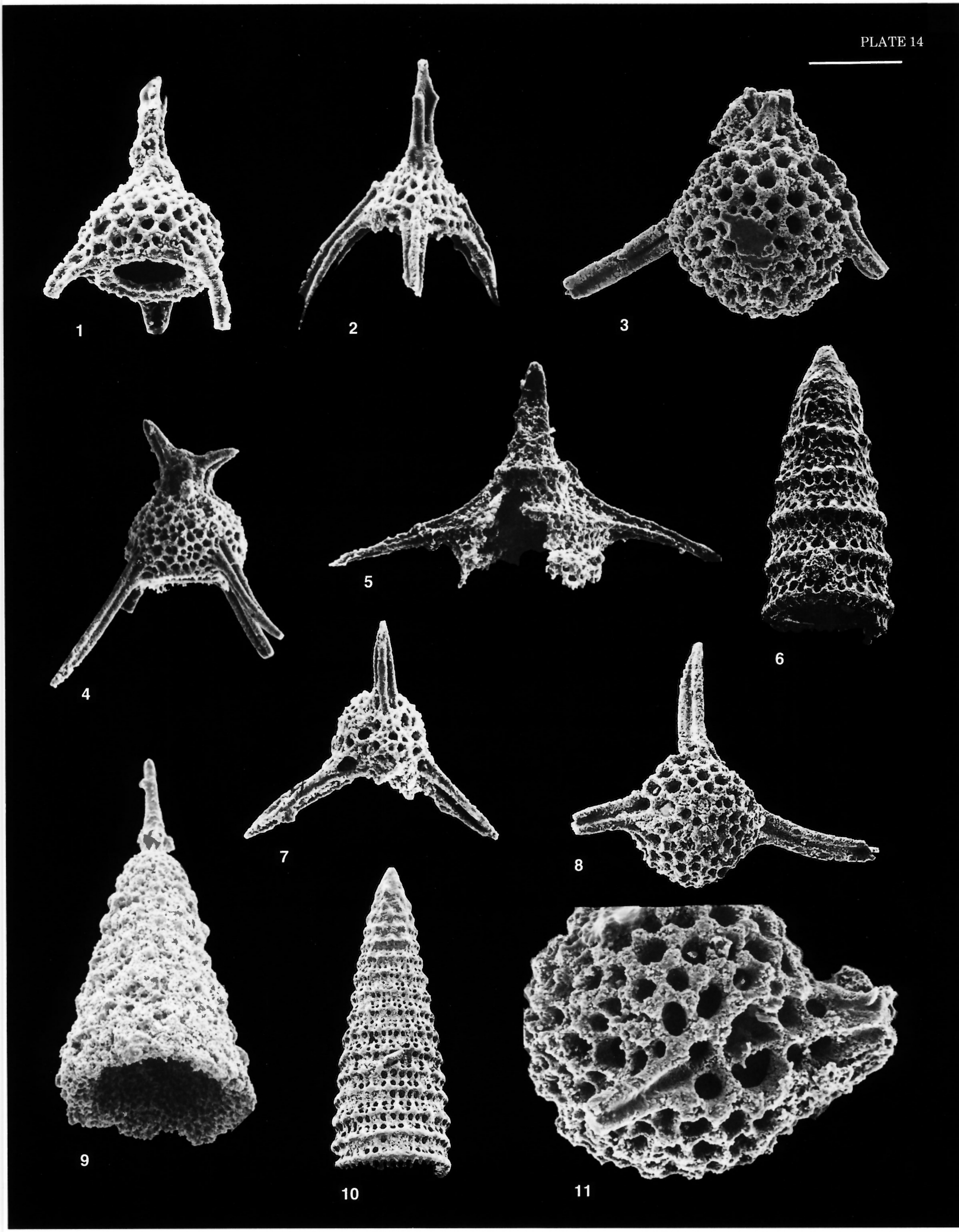
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PLATE 15

Scanning electron micrographs of Middle Jurassic (Aalenian - lower Bajocian) Radiolaria from the Phantom Creek and Graham Island formations, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1, 2. *Parvicingula* sp. D (page 56)

GSC 80669, GSC loc. C-080586, Aalenian; scales = 75 and 69 μm, respectively.

Figure 3. *Hsuum* sp. aff. *H. belliatulum* Pessagno and Whalen (page 52)

GSC 80643, GSC loc. C-080586, Aalenian; scale = 129 μm.

Figure 4. *Hsuum* sp. cf. *H. mirabundum* Pessagno and Whalen (page 52)

GSC 80644, GSC loc. C-080595, early Bajocian; scale = 120 μm.

Figure 5. *Hsuum* (?) sp. C (page 53)

GSC 80675, GSC loc. C-080594, early Bajocian; scale = 89 μm.

Figure 6. *Perispyridium* sp. B (page 59)

GSC 80682, GSC loc. C-080595, early Bajocian; scale = 115 μm.

Figure 7. *Stichocapsa* sp. aff. *S. japonica* Yao (page 62)

GSC 80693, GSC loc. C-080594, early Bajocian; scale = 89 μm.

Figure 8. *Emiluvia* sp. E (page 36)

GSC 80554, GSC loc. C-080589, early Bajocian; scale = 133 μm.

Figures 9, 12. *Crucella* sp. A (page 43)

GSC 80593, GSC loc. C-080593, early Bajocian; scales = 184 and 65 μm, respectively.

Figure 10. *Lophodictyotidium* sp. cf. *L. sarjeanti* Pocock (page 63)

GSC 80705, GSC loc. C-080590, early Bajocian; scale = 50 μm.

Figures 11, 13. Genus A, undet. (page 63)

GSC 80704, GSC loc. C-080586, early Bajocian; scales = 98 and 45 μm, respectively.

PLATE 15

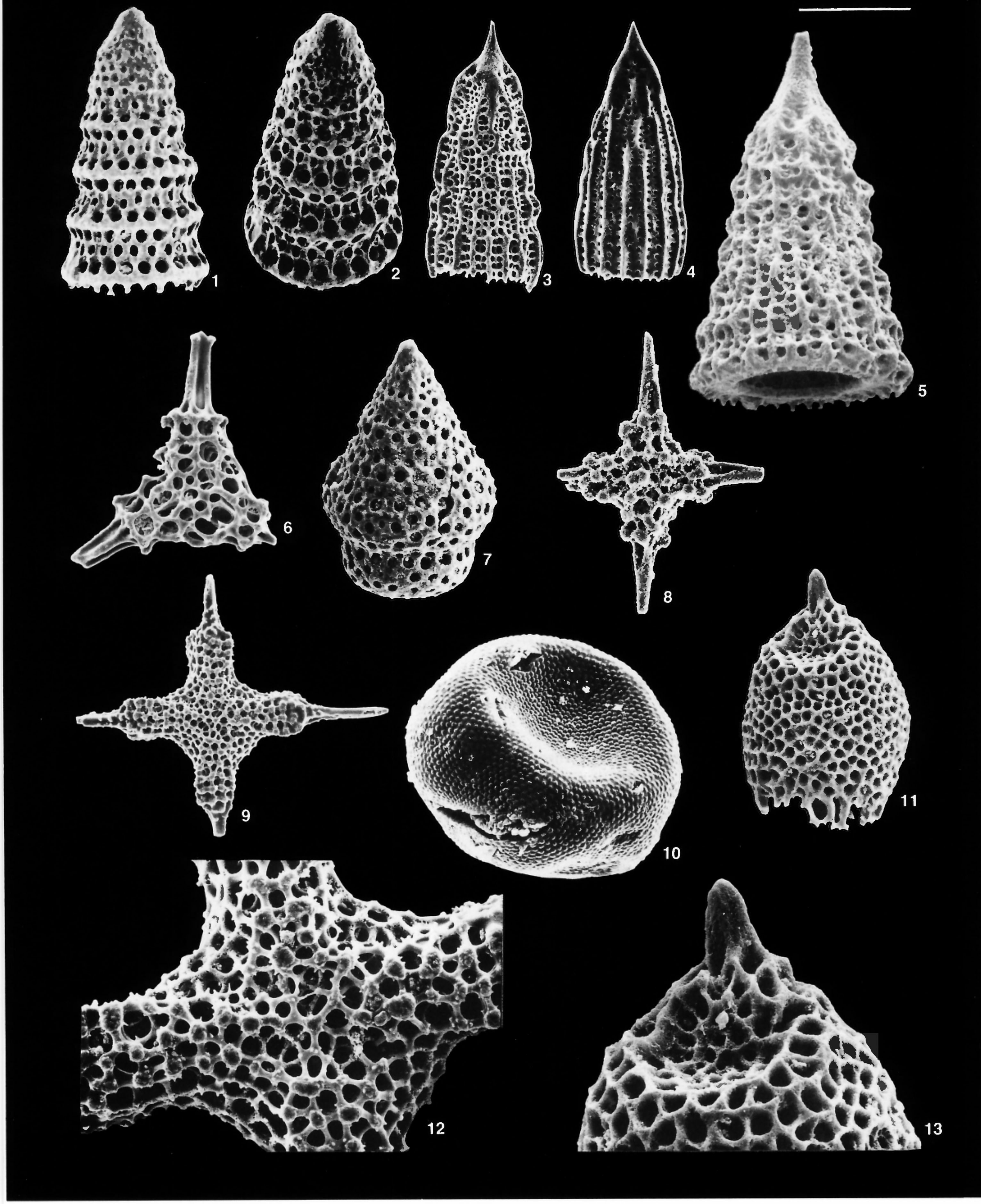

PLATE 16

Scanning electron micrographs of Middle Jurassic (lower Bajocian) Radiolaria from the Graham Island Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figure 1. *Trillus* sp. cf. *T. seidersi* Pessagno and Blome (page 38)

GSC 80563, GSC loc. C-080592, early Bajocian; scale = 124 μm.

Figures 2, 10. *Zartus thayeri* Pessagno and Blome (page 38)

GSC 80565, GSC loc. C-080592, early Bajocian; scales = 127 and 48 μm, respectively.

Figures 3, 4. *Emiluvia acantha* n. sp. (page 34)

4, holotype, GSC 80542, GSC loc. C-080596; 3, paratype, GSC 80543, GSC loc. C-080588, early Bajocian; scale = 76 μm.

Figures 5, 11. *Emiluvia splendida* n. sp. (page 35)

5, holotype, GSC 80540; 11, paratype, GSC 80541, GSC loc. C-080595, early Bajocian; scales = 103 and 47 μm, respectively.

Figure 6. *Emiluvia oldmassetensis* n. sp. (page 35)

Holotype, GSC 80553, GSC loc. C-080595, early Bajocian; scale = 100 μm.

Figure 7. *Homeoparonaella* sp. aff. *H. elegans* (Pessagno) (page 28)

GSC 80504, GSC loc. C-080587, early Bajocian; scale = 109 μm.

Figure 8. *Tetraditryma* sp. B (page 31)

GSC 80520, GSC loc. C-080595, early Bajocian; scale = 108 μm.

Figures 9, 12. *Tetraditryma* sp. A (page 31)

GSC 80519, GSC loc. C-080587, early Bajocian; scales = 111 and 45 μm, respectively.

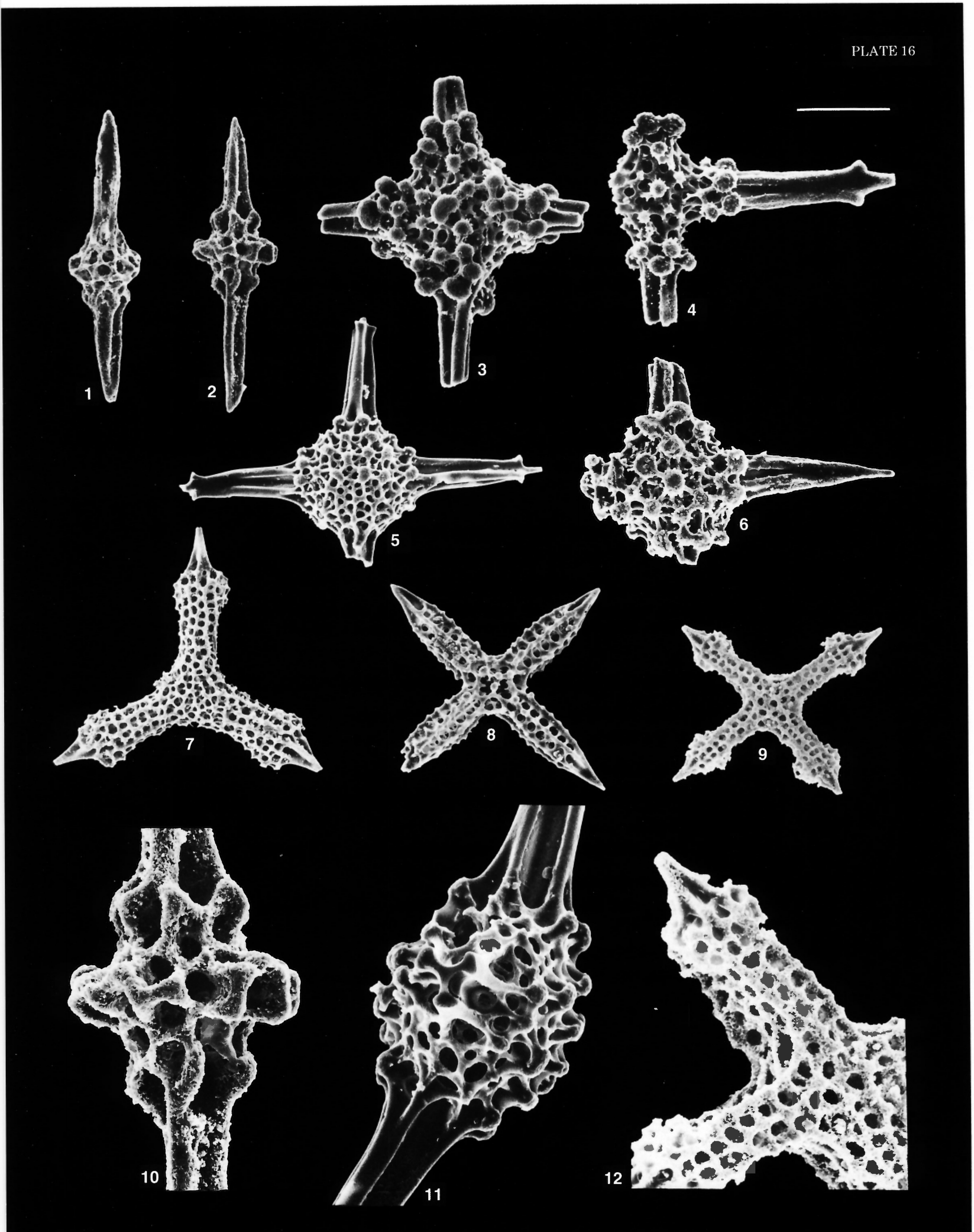

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PLATE 17

Scanning electron micrographs of Middle Jurassic (lower Bajocian) Radiolaria from the Graham Island Formation, Graham Island, Queen Charlotte Islands, B.C. Bar scale = number of µm cited for each specimen illustrated.

Figure 1. ?*Paronaella denudata* (Rüst) (page 39)

GSC 80569, GSC loc. C-080588, early Bajocian; scale = 81 µm.

Figure 2. *Paronaella tlellensis* n. sp. (page 41)

Holotype, GSC 80573, GSC loc. C-080595, early Bajocian; scale = 100 µm.

Figure 3. *Paronaella* sp. F (page 43)

GSC 80589, GSC loc. C-080594, early Bajocian; scale = 115 µm.

Figures 4, 5. *Spongostaurus pugiunculus* n. sp. (page 45)

4, holotype, GSC 80604; 5, paratype, GSC 80605, both specimens from GSC loc. C-080595, early Bajocian; scales = 119 and 90 µm, respectively.

Figure 6. *Praeconocaryomma* sp. aff. *P. universa* Pessagno (page 32)

GSC 80527, GSC loc. C-080588, early Bajocian; scale = 54 µm.

Figures 7, 8. *Hsuum* sp. aff. *H. mirabundum* Pessagno and Whalen (page 52)

7, (No. 2, 'related form': see text) GSC 80645; 8, (No. 3, see text) GSC 80646, GSC loc. C-080595, early Bajocian; scale = 100 µm.

Figure 9. *Mita* sp. A (page 49)

GSC 80623, GSC loc. C-080595, early Bajocian; scale = 77 µm.

Figure 10. *Praeconocaryomma* sp. aff. *P. californiensis* Pessagno (page 32)

GSC 80526, GSC loc. C-080587, early Bajocian; scale = 82 µm.

Figure 11. *Parvicingula* sp. F (page 56)

GSC 80671, GSC loc. C-080594, early Bajocian; scale = 64 µm.

Figure 12. *Droltus* sp. A (page 49)

GSC 80625, GSC loc. C-080593, early Bajocian; scale = 72 µm.

Figure 13. *Eucyrtidium elementarius* n. sp. (page 60)

Holotype, GSC 80686, GSC loc. C-080595, early Bajocian; scale = 103 µm.

Figure 14. *Eucyrtidium* (?) sp. A (page 60)

GSC 80688, GSC loc. C-080592, early Bajocian; scale = 64 µm.

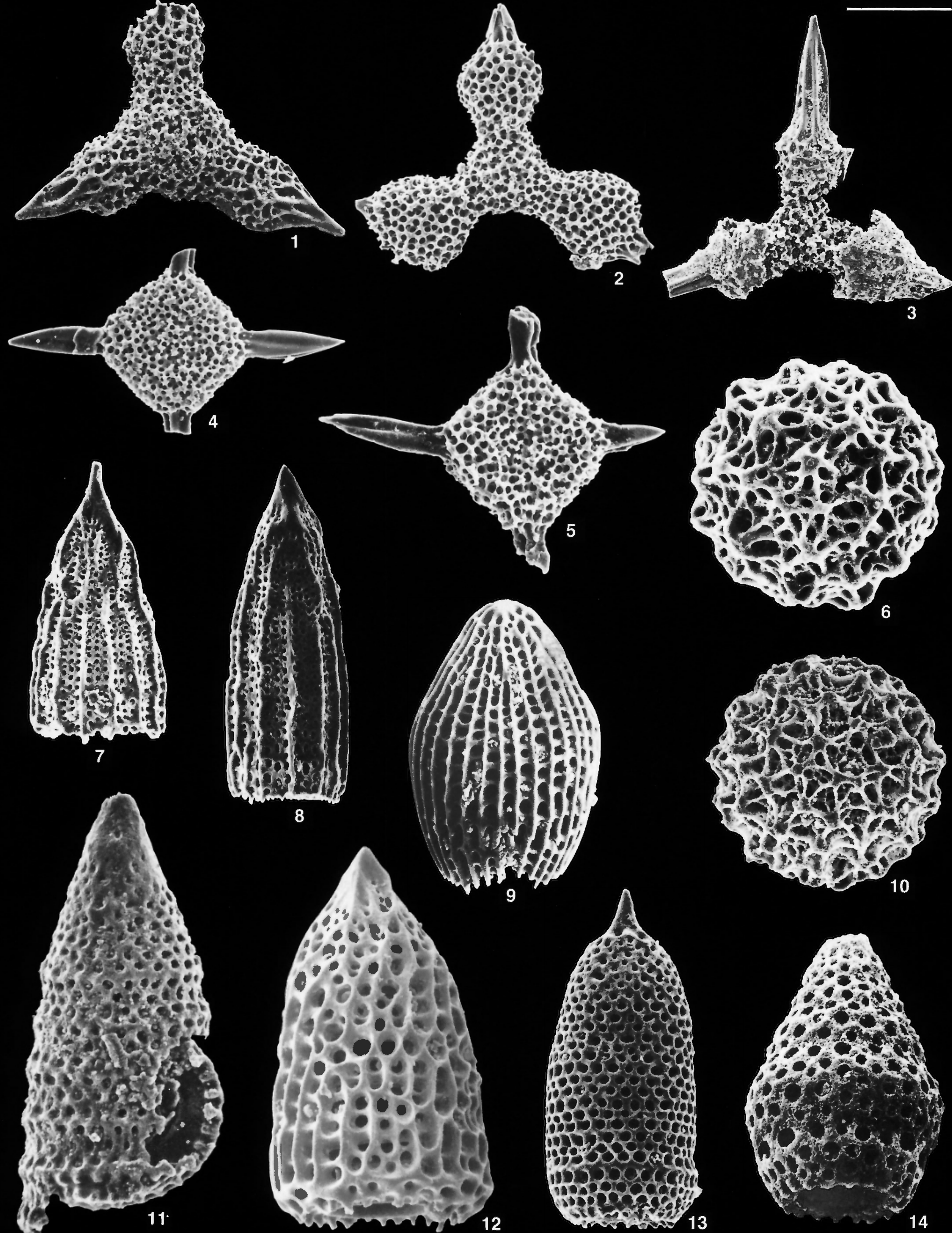
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PLATE 18

Scanning electron micrographs of Middle Jurassic (lower Bajocian) Radiolaria from the Graham Island Formation, Queen Charlotte Islands, B.C. Bar scale = number of μm cited for each specimen illustrated.

Figures 1, 2, 7. *Parvicingula aculeata* n. sp. (page 54)

1, 7, holotype, GSC 80644; 2, paratype, GSC 80665, GSC loc. C-080595, early Bajocian; scales = 120, 42, and 114 μm, respectively.

Figures 3, 4. *Parvicingula* sp. B (page 56)

3, GSC 80666; 4, paratype, GSC 80667, GSC loc. C-080595, early Bajocian; scales = 100 and 125 μm, respectively.

Figure 5. *Parvicingula* sp. C (page 56)

GSC 80668, GSC loc. C-080595, early Bajocian; scale = 114 μm.

Figures 6, 12, 16. *Parvicingula matura* Pessagno and Whalen (page 55)

GSC 80658, GSC loc. C-080595, early Bajocian; scales = 96, 100, and 43 μm, respectively.

Figures 8, 10, 15. *Parvicingula* sp. aff. *P. burnensis* Pessagno and Whalen (page 55)

8, GSC 80659, GSC loc. C-080588; 10, 15, GSC 80660, GSC loc. C-080594, early Bajocian; scales = 89, 104, and 51 μm, respectively.

Figures 9, 11. *Parvicingula* sp. aff. *P. media* Pessagno and Whalen (page 55)

GSC 80662, GSC loc. C-080595, early Bajocian; scales = 71 and 114 μm, respectively.

Figures 13, 14. *Parvicingula* sp. aff. *P. profunda* Pessagno and Whalen (page 55)

GSC 80663, GSC loc. C-080595, early Bajocian; scales = 45 and 75 μm, respectively.

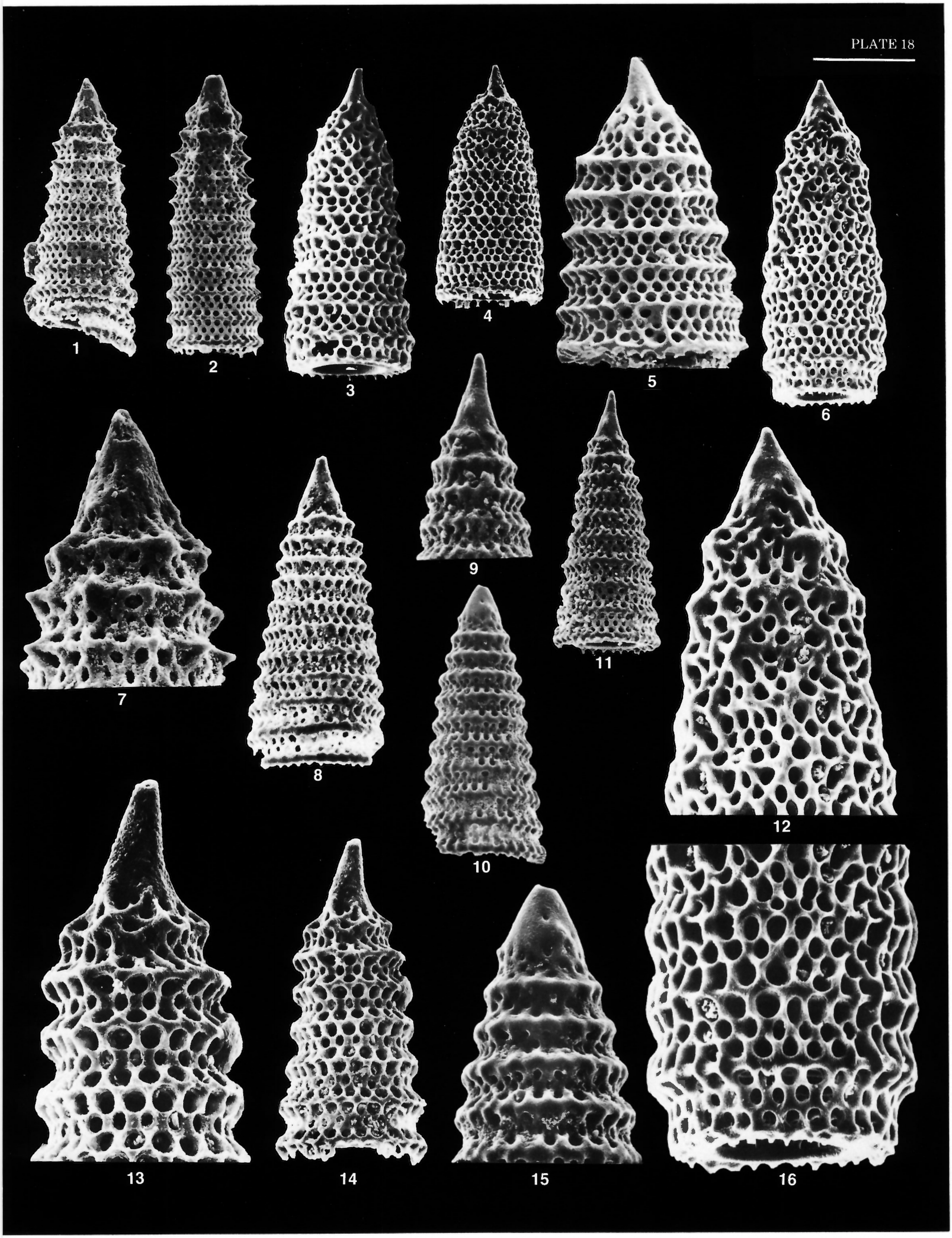

PLATE 18